INSTITUTE FOR MARINE AND ANTARCTIC STUDIES
UNIVERSITY OF TASMANIA

SURVEYS OF INTERTIDAL AND SUBTIDAL BIOTA OF THE DERWENT ESTUARY – 2010

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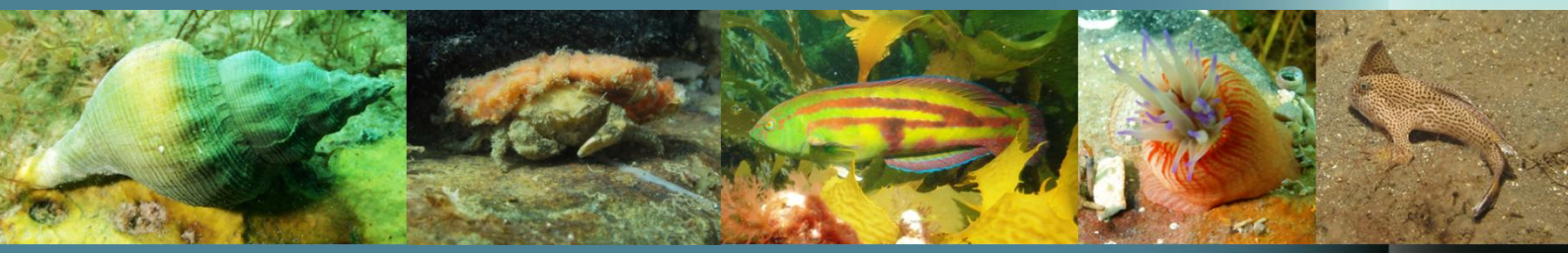

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Summary

This study examines patterns of diversity and abundance of fish, invertebrates and algae on intertidal to subtidal rocky reefs and their adjacent sediments within the Derwent Estuary. It is based on two quantitative survey methods that formed the basis of a detailed survey of the estuary, primarily undertaken between February-April 2010. The survey area ranged from Claremont Point to Tinderbox and encompassed up to 24 sites along this estuarine gradient, surveying the typical range of depths that rocky reefs and adjacent sediments occur in along that gradient. The primary aims of the study were: (1) to provide a substantial quantitative baseline of current biological assemblages in these habitats as a snapshot by which future change could be measured, spatial patterns could be recognised, and management issues identified; (2) to undertake a detailed search for the threatened seastar *Marginaster littoralis*, and other rare seastar species that could be resident in the Derwent estuary to better understand their conservation status; (3) to quantitatively describe the current distribution of introduced species within the estuary and better understand the threats they might provide to native species.

The two survey methods utilised included (1) a standard belt transect methodology widely used by TAFI for biodiversity surveys in temperate Australia; (2) a 20 minute timed swim (and intertidal search) with multiple replicates at multiple depth bands, recording fishes, readily identifiable fishes, invertebrates and brown and green macroalgae. For method 1, fifty four species of fish, thirty five species of mobile macro-invertebrates, twenty one species of sessile invertebrates and seventy two species of brown, green and red algae were recorded along standard subtidal rocky reef surveys. Fish, invertebrate and algal diversity generally increased from northern to southern-most sites within the estuary, in a pattern typical of estuarine diversity gradients. Fish species such as *Trachinops caudimaculatus* (Hulafish), *Latridopsis forsteri* (Bastard trumpeter), *Dinolestes lewini* (Long-fin pike), *Notolabrus tetricus* (Blue-throat wrasse) and *Acanthaluteres vittiger* (Toothbrush leatherjacket) were the most abundant. The abundance of these species increased towards the southern sites of the estuary with the exception of Hulafish which were more abundant towards the northern parts of the estuary. The most abundant invertebrates were the echinoderms *Patiriella regularis* (introduced regular seastar), *Heliocidaris erythrogramma* (Purple urchin), *Meridiastra calcar* (Eight-armed seastar), *Amblypneustes ovum* (Short-spined urchin) and the Triton shell *Cabestana spengleri*.

Introduced species of echinoderms and crustaceans were more abundant in the northern sites of the estuary whereas native invertebrates were more abundant in the southern part of the estuary. Overall, introduced species numerically dominated the mobile macro-invertebrates within the estuary from Claremont Point to Bellerive Bluff. Dominant algae included species of encrusting *Peyssonnelia* (red algae) and the brown kelp *Ecklonia radiata*, *Lessonia corrugata* and *Carpoglossum confluens*, but the distribution of most foliose algae was restricted to sites seaward of Rosny Point, with filamentous red algae in particular dominating the northern section of the estuary. Bellerive Bluff to Rosny Point marked the most significant transition in algal assemblages and corresponded with a change from silty tube-worm matting dominated reef systems to reefs with an increasing cover of encrusting corraline algae and encrusting sponges. Notable features of the algal surveys included the abundance of the red algae *Aodes nitidissima* in the Rosny Point region where other foliose algae are rare, and the presence of the North Pacific kelp *Undaria pinnatifida* between the Grange and

Alum Cliffs. *Undaria* is an introduced species of brown algae that is seasonally abundant with peaks in early summer. We suspect that *Aodes* is also an introduced species given its restricted range in this survey and the distribution of past specimens collected in Tasmania that are also restricted to the estuary.

For method 2, seventy four species of fish, one hundred and forty seven species of macro-invertebrates and forty six species of brown and green algae were recorded throughout the timed intertidal and subtidal surveys. As with results from standard surveys, diversity of fish, invertebrate and algae increased from northern to southern-most sites within the estuary. Fish species such as *T. caudimaculatus*, *N. tetricus*, *Fosterygion varium* (introduced Many-rayed threefin), *Grahamina gymnota* (introduced Estuarine threefin) and *Neoodax balteatus* (Little rock whiting) had the largest rank abundances. Spatial distribution patterns were clearest for the two introduced threefin species which were most strongly associated with the mid-upper estuarine sites. The upstream assemblage was characterised by high abundance of gobies, blennies and threefins.

A similar, but reversed pattern was evident with many marine species, particularly the numerically abundant *N. tetricus*, a species essentially absent upstream from Rosny Point. The most abundant invertebrates were *Mytilus galloprovincialis* (Blue mussel), *Petrolisthes elongatus* (introduced New Zealand porcelain crab), the introduced echinoderms *Asterias amurensis* (Northern Pacific seastar), *P. regularis* and the introduced fan worm *Myxicola infundibulum*. Some clear patterns of species distribution occurred along the estuary, including an increased abundance of *P. regularis* at sites upstream from Bellerive Bluff and high abundance of *M. calcar* at sites seaward of that location. For algae, the most abundant brown and green taxa were *Ulva* spp., *E. radiata*, *Codium fragile*, *L. corrugata* and *Dictyopteris muelleri*. These algae generally increased towards the southern part of the estuary with the exception of *Ulva* spp., which was consistently present in most sites. Most foliose algae were not present at sites upstream of Bellerive Bluff. *Ecklonia radiata*, present at Bellerive Bluff in depths to below 5 m, was not present at Rosny Point at any depth, despite the close proximity, indicating a very strong environmental gradient between these sites that was also reflected in the distribution of many other species, and the extent of cover of silt laden tube-worm matting that was prevalent across depths at the more upstream sites.

Overall, this survey has successfully provided a comprehensive quantitative snapshot of the current distribution of much of the epifaunal biodiversity associated with reef systems in the Derwent estuary. It revealed many strong spatial patterns in species distributions and should provide a robust baseline from which to measure and assess future change. The clear break in biological assemblages between Rosny Point and Bellerive Bluff deserves further investigation to assess causes underlying this, including the extent that the tube-worm matting dominating the reef at Rosny Point and upstream sites plays. This matting may represent an alternative stable state to the algal dominated reef historically described from Rosny Point, the restoration of which may be seen to be an ultimate management goal with respect to amelioration of human impacts within the estuary.

Despite thorough searching for the presence of the threatened Derwent river seastar *Marginaster littoralis*, none were found. This is despite extensive searching both intertidally and subtidally within the core habitat of this species. The co-occurrence and super-abundance of *P. elongatus* and *P. regularis* in these habitats suggests that if any individuals of *M. littoralis* are left they would be subject to severe competition and

predation by these species. Consideration of the difficulty of exploiting an intertidal habitat within the core range of *M. littoralis* suggests that winter low salinity coupled with summer desiccation during spring tides and high temperatures would make an obligate mid-estuarine intertidal niche' impossible. If the species is valid and continues to persist, in addition to the intertidal zone it is described from, it must also occupy subtidal habitats below salinity lows during winter, or additional intertidal habitats away from the influence of physical extremes. Our searches included many of these habitats but failed to detect any specimens. As *P. regularis* displayed great morphological variability within the central area of occupancy of *M. littoralis*, some specimens of which displayed similar features (such as an off-white marginal fringe), we suggest a revision of the taxonomy of this species be undertaken with regard to the variability of *M. calcar* characters, and a molecular genetic comparison to be made between these species once molecular techniques evolve to cope with the formalin preserved type specimens.

Despite the rare species focus of our surveys, and the possibility of encountering several species of rare seastars known from adjacent coastal areas, no such species were found. If they are present, they would presumably be in low numbers and in isolated populations. Clearly, such species are difficult to detect, and require greater intensity of search effort to delineate their range than was possible in this survey. This was illustrated from our soft sediment searches undertaken adjacent to the reef margins, as these searches detected only one Spotted handfish *Brachionichthys hirsutus* despite many of our survey sites falling within the range and core habitat of this species.

Introduced species numerically dominate the mobile invertebrate fauna at most of the sites we surveyed upstream from Bellerive Bluff. At many sites they contributed well over 80% of all invertebrate individuals counted along transects. In addition to the species described previously, they include the Piecrust crab (*Metacarcinus novaezelandiae*) and the green shore crab (*Carcinus maenus*), a species recently established in the estuary. A similar pattern is evident with sedentary invertebrates, with the Pacific oyster (*Crassostrea gigas*) distributed throughout the estuary and being particularly abundant in the upper sites examined. The fanworm *Myxicola infundulibulum* was abundant throughout soft silty sediments. Two species of introduced threefin *Fosterygion varium* and *Grahamina gymnota* were abundant in mid estuarine sites (Bedlam Walls to Bellerive Bluff) and several introduced species of algae were found at the more seaward sites. These were the large brown algae *Undaria pinnatifida* and the recently arrived red algae *Grateoloupia turuturu.* A further species of red algae, *Aodes nitidissima* is also suspected to be introduced, due to its restricted range within mid-estuarine sites. Many of these introduced species are in pest abundances, and the super-abundance of *P. elongatus* and *P. regularis* at many sites clearly threaten a range of native species at these sites and suggests that they may pose a biodiversity threat more widely, particularly to rare species such as *Parvulastra vivipara* and *Smilasterias tasmaniae,* seastars that occupy similar sheltered rocky shoreline habitats in nearby environments. Further investigation is urgently needed to quantify the threats that abundant introduced taxa pose.

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1. Introduction

Despite the Derwent estuary being adjacent to Tasmania's capital city, very little has been quantitatively described with respect to the reef based biota, or the biota on sediment habitats adjacent to these reefs. Most recent quantitative work has been related to describing the impact of introduced pests such as the seastar *Asterias amurensis* (Ross *et al.*, 2006, Ling 2000), the protection of the threatened Spotted handfish populations (Bruce *et al.*, 1999), or the restoration of historic giant kelp population (Sanderson, 2000), rather than describing overall species distributions. Major factors that have contributed to the lack of prior broad-scale ecological investigations include a paucity of funding for such baseline initiatives and water quality. The latter factor often severely limits underwater visibility and thus the time periods and locations in which visual surveys can be undertaken.

Given that species and habitats within the estuary are under significant threat from a wide range of sources, including habitat loss, siltation, organic enrichment, altered environmental flows, heavy metal contamination and infestation by introduced marine pests (Whitehead *et al.*, 2010), and that the estuary is home to several listed threatened species including the spotted handfish (Last *et al*., 1983) and the Derwent River seastar (*Marginaster littoralis*; Dartnall, 1970), a detailed biodiversity survey of the current status of the estuary is long overdue. Historical records suggest giant-kelp forests were once present up the river at least as far as Rosny Point (Sanderson, 2000), but the current absence of any kelp at this location, coupled with the failure of Seacare's attempts to re-establish kelp populations in this region (Sanderson, 2000), indicates that the distribution of species within the estuary has been severely impacted by human activities. Despite attempts to restore water quality (Whitehead *et al*., 2010), conditions have yet to return to a state where restoration of historical species distributions is possible.

The Derwent estuary falls within the Bruny Bioregion, an area characterised by an anomalously high marine species endemism (Edgar *et al.*, 1999), presumably due to this being the southernmost Australian biogeographical region that encompasses sheltered waterways such as the D'Entrecasteaux Channel and Derwent estuary. Many of the endemic species are listed as threatened under either Tasmanian or Commonwealth legislation, and many additional species are likely to be under threat in the future due to a changing climate and human impacts on their habitat.

While currently only *M. littoralis* and *B. hirsutus* have been described from the Derwent, it is likely that other rare and endemic species are present, as some sheltered habitats fall within the geographical range of species such as the red handfish (Bruce *et al.*, 1998), live bearing seastar (*Parvulastra vivipara*) or are close to populations of species such as the Tasmanian seastar *Smilasterias tasmaniae* (found in the upper D' Entrecasteaux- Materia, 1994). Clearly, any populations within the Derwent could be under threat from a range of anthropogenic stressors, and identifying the occurrence of such populations is an important goal for conservation management and planning.

One component of particular interest to conservation management is the current status and distribution of the seastar *M. littoralis*. This intertidal species has only been

recorded from the mid-section of the Derwent Estuary between Selfs Point and Macquarie Point, within the range from which it was first described (Dartnall, 1970). Despite some nominal records attributed to this species being found as late as 2004 (DPEWH, 2010), the latest confirmed records held by the Museum of Tasmania date back to 1970 (Liz Turner, pers. comm.; Bryant and Jackson, 1999). An extensive intertidal search for this species was undertaken in 1994 (Materia 1994a), with no success, although there remains the possibility that subtidal populations still exist in this area.

This study was initiated as a first attempt to quantitatively fill some of the information gaps with respect to the distribution of reef associated biodiversity within the Derwent Estuary, and builds an additional detailed layer on recent initiatives (Jordan *et al.*, 2001; Lucieer *et al.*, 2007) to map the overall distribution of key biological habitats within this system. We had three primary aims:

(1) To use systematic quantitative methods to survey the biodiversity associated with a broad geographical range of reef systems within the estuary, and over a range of depths, including the intertidal zone. This dataset would provide a snapshot of the current status of biodiversity within the system, describing spatial patterns and acting as a baseline by which future changes can be measured. It would also inform management agencies of obvious problems within this system, allowing appropriate management actions to be developed.

(2) To thoroughly survey both subtidal and intertidal habitats within the core known range of M. *littoralis* for any evidence of a surviving population. The discovery of any population would allow targeted species recovery plans to be developed, and facilitate conservation planning to protect its remaining habitat.

(3) To quantitatively describe the distribution and abundance of introduced species throughout the estuary to more adequately describe the nature of the problem and the potential threats that these species may present to native biodiversity.

2. Methods

A mix of methods were utilised during this survey to both adequately describe the distribution of reef associated biodiversity within the Derwent estuary, and to establish robust quantitative baseline datasets as effective references from which to measure future change. Overall, the diversity and abundance of fish, invertebrates and algae were surveyed on subtidal rocky reefs within the Derwent Estuary in March 2009 (2 sites) and February-April 2010 (17 sites) by a transect-based method. Additional timed surveys of the same biota were undertaken on intertidal and subtidal reef, sand and ecotone (reef-sand) habitats at different depths. These surveys recorded the diversity and rank abundance of both common and rare species during February-April 2010 (24 sites). One final component involved a series of thorough (untimed) intertidal surveys specifically for *M. littoralis,* that were undertaken opportunistically between October 09 and February 2010 at a range of locations within the area of occupancy originally described for *M. littoralis,* ranging from Macquarie Point (Powder Jetty at Regatta Ground boat ramp) to Selfs Point (outer northern tip of Cornelian Bay). These surveys were undertaken at low tides, and included a collection of surveys by DEP staff, TAFI staff and volunteers.

2.1 Standard subtidal reef surveys

The standard monitoring method described below involves the underwater visual census (UVC) of densities of fish, mobile macro-invertebrates and algae along 200 m transects at replicate sites to document diversity, abundance and distribution of biota and quantify biological changes in different areas. This method was primarily designed for shallow rocky reef communities. It provides the most effective way of monitoring species at shallow-water sites because methods are non-destructive and large amounts of data on a broad range of species can be collected within a short dive period. It has been previously used in MPA monitoring programs (Edgar & Barrett 1997, 1999; Barrett & Buxton 2002), to cover a range of taxa and assess previously undetected effects of fishing in these areas.

A 2-4 person dive team was used to survey 19 sites in the Derwent Estuary during February to April 2010 (Table 1; Fig. 1–3). In this report we also include data from two additional sites surveyed in April 2009 (Lucas Point and Pearsons Point) to complete the spatial coverage of the estuary, giving a range from Cadbury Point to Pearsons Point. At each site, two 100 m long transect lines were laid out in opposite directions, starting at the boat anchor. Each 100 m transect line was divided into two 50 m segments, making 4 x 50 m transect blocks for each depth interval surveyed.

Fish were surveyed by counting the number of species in 5 m wide swathes, up one side of the 50 m transect line then back along the other side, making a total of 4 x 10 m x 50 m fish transects surveyed at each site. The size of individual fish was also recorded. At the Claremont and Bedlam Walls sites, restricted visibility meant that counts could only be taken over 2 m wide swathes on either side of the line.

Cryptic fish and mobile macro-invertebrates were surveyed by searching the seabed within a distance of 1 m from the transect line. This included all visible crevices and overhangs but not overturning boulders. Algae were swept away from the transect line to obtain a clear view of the substratum. A total of 4 x 1 m x 50 m transects were surveyed at each site. Cryptic fish were also identified and counted.

The cover of macroalgae, sessile invertebrate species and substrata was quantified by placing a grided 0.25 m^2 quadrat at 10 m intervals along the transect lines (i.e. 20 quadrats per 200 m transect). Covers was assessed by identifying and counting all layers (understory, overstory) of species that occurred directly under 50 (49 plus one corner) intersection points. This allowed their percentage covers to be quantified.

For this particular survey, one additional method was used to quantify benthic cover and species composition. We took high resolution (18Mb) images of approximately 0.25 m2 of the seabed at intervals of 5 m along each transect line. These images were not analysed as part of this study, but remain as an archived permanent record for future studies. Attached as Appendix 8 (DVD) to this report.

At many of the reef systems in the mid-upper estuarine sites reef systems often did not occur at 5 m depth, the standard depth of surveys using these methods at other locations. Moreover, some reefs extended for significantly less length than 200 m, the full distance normally surveyed. To counter this, surveys were undertaken at the maximum depth possible (1 m for Cadburys Point), and, at sites with only small patches of reef, two transects (instead of four) were completed. Where only two transects were undertaken, an additional invertebrate search was undertaken on the opposite side of the transect line to give four surveyed blocks per site. Details of sites and depths sampled as well as the number of transects surveyed per site are in Table 1 and Figures 1–3.

2.2 Timed intertidal and subtidal surveys

Timed intertidal and subtidal surveys were undertaken to accurately and efficiently record the diversity and rank abundances of common and rare species across the depth range of reef systems within the study area, and, where possible (due to access and visibility constraints), also over soft sediment habitats adjacent to the reef systems to capture the habitat of known rare species such as the spotted handfish. Some of these transects were recorded as “ecotone” as they were comprised a mix of patch reef and open sediments near the reef boundary, containing a mix of reef and sediment associated species. As well as describing a broader range of depths and habitats than the quantitative transect surveys, this method has a higher chance of detecting rare species, such as *M. litoralis* or spotted handfish, as their core habitat is specifically covered by the survey technique.

At each of 24 sites, fish, macro-invertebrates, brown and green algae and introduced or "key" species of red algae were recorded on replicated timed 20 min searches. These were undertaken between February and March, 2010 (Table 1, Fig. 1–3). Searches were undertaken at different depth ranges (intertidal, 0 – 0.9 m, 1 – 4.9 m, 5 – 8.9 m, 9 – 15 m) in reef, sand and ecotone (reef-sand) habitats. A 2–4 person team was used to survey each site, with one timed survey undertaken by each person at each depth band. When a particular species was present, its abundance was ranked in the categories 1 (only one specimen observed), 2 (2 – 10), 3 (11–100), 4 (101 – 1000) and 5 (> 1000). The first 10 minutes of a survey were generally used documenting all the most common (abundant) species encountered. The last 10 minutes were targeted at searching for less common species including searching crevices and turning over boulders to document species found underneath. Where possible, a minimum of ten boulders were turned on each transect (on reef habitat) but some sites had few or no boulders that could be turned. Red algae were generally excluded from the surveys as they are difficult to identify to the species level in the field, and their diversity is generally so high in open waters that recording their presence severely restricts time available for other target species.

While subtidal searches were aimed at covering the greatest variety of depths and habitats, not all habitats were present at each site or could be surveyed due to time constraints or lack of underwater visibility. Details of sites, depths and habitats sampled as well as the number of timed searches surveyed per site are in table 1 and Figures 1–3.

Intertidal searches were undertaken at all sites, and were restricted to rocky shoreline habitat. Wherever possible, at least ten boulders/large rocks were turned at each site to gain an indication of the abundance of cryptic species. Some sites, such as Bellerive Bluff with sandstone platform, lacked boulders and hence boulder associated species. For the *M. littoralis* specific searches, searching was thorough and often undertaken at spring low tides to maximise the area and depth range able to be searched. Multiple boulders/rocks were overturned and all rock pools searched thoroughly. Very few rock pools were present within the historical range described by Dartnall (1970).

Table 1. Details for standard and timed surveys conducted in the Derwent in 2010. Positions are recorded in decimal degrees using WGS 84.

SITE DETAILS			STANDARD SURVEYS		TIMED SURVEYS		
N	**Name**	**Latitude**	**Longitude**	**Depth (m)**	**Number of transects**	**Depth range (m)**	**Habitat**	**Number of searches**
1	Cadbury Point	-42.7885	147.2810	1	2	Intertidal	Reef	2
						1.1 – 4.9		2
2	Dowsings Point	-42.8184	147.2977			Intertidal	Reef	2
						0 – 1	Ecotone	1
							Reef	1
3	Bedlam Walls North	-42.8320	147.3273	4	2	Intertidal	Reef	2
						1.1 – 4.9	Reef	2
4	Bedlam Walls South	-42.8379	147.3312	4	2	Intertidal	Reef	2
						1.1 – 4.9	Reef	2
5	Point South of Gielston Bay	-42.8443	147.3376	3	2	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Ecotone	2
							Reef	3
						5 – 8.9	Sand	1
6	Cornelian Bay	-42.8518	147.3279	2	2	Intertidal	Reef	2
						0 – 1	Reef	1
						1.1 – 4.9	Reef	2
							Sand	1
7	200 m North Tasman Bridge East Shore	-42.8610	147.3501	2	2	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Ecotone	2
							Reef	2
						5 – 8.9	Sand	2
8	Collegiate Rowing Club	-42.8636	147.3362			Intertidal	Reef	2
						0 – 1	Reef	2
9	Rosny Point North	-42.8719	147.3504	4	2	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Reef	2
						5 – 8.9	Sand	3
10	Naval Cadets	-42.8724	147.3355			Intertidal	Reef	2
						0 – 1	Reef	2
11	Bellerive Yacht Box	-42.8757	147.3619			5 – 8.9	Sand	2
12	Rosny Point South	-42.8762	147.3543			5 – 8.9	Sand	2
13	Bellerive Bluff	-42.8820	147.3652	4	2	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Ecotone	3
						5 – 8.9	Ecotone	1
							Sand	2
						9 – 15	Sand	1
14	Bellerive/Howrah Bluff	-42.8825	147.3854	5	2	Intertidal	Reef	2
						0 – 1	Reef	2
						1.1 – 4.9	Reef	2
						5 – 8.9	Sand	1
						9 – 15	Ecotone	2
15	Battery Point	-42.8897	147.3394	2	2	Intertidal	Reef	2
						0 – 1	Reef	2
						5 – 8.9	Sand	1
16	Tranmere Reef	-42.8999	147.4095			5 – 8.9	Reef	1
17	Tranmere Point	-42.9304	147.4093	3	4	Intertidal	Reef	3
						0 – 1	Reef	2
						1.1 – 4.9	Ecotone	1
							Reef	1
							Sand	1
						5 – 8.9	Reef	1

Table 1. cont. Details for standard and timed surveys conducted in the Derwent in 2010. Positions are recorded in decimal degrees using WGS 84. * surveys completed in 2009.

SITE DETAILS				STANDARD SURVEYS		TIMED SURVEYS		
N	**Name**	**Latitude**	**Longitude**	**Depth (m)**	**Number of transects**	**Depth range (m)**	**Habitat**	**Number of searches**
18	The Grange, Taroona	-42.9326	147.3616	4	2	Intertidal	Reef	2
						0 – 1	Reef	2
						1.1 – 4.9	Reef	2
						5 – 8.9	Ecotone	2
19	Crayfish Point	-42.9521	147.3560	4	4	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Reef	2
						5 – 8.9	Reef	2
							Sand	1
20	Alum Cliffs	-42.9666	147.3419	5	4	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Reef	2
						5 – 8.9	Ecotone	1
							Sand	1
21	Mary-Ann Bay	-42.9726	147.3996			5 – 8.9	Sand	2
22	White Rock, South Arm	-42.9774	147.3923	4	4	Intertidal	Reef	3
						0 – 1	Reef	2
						1.1 – 4.9	Reef	2
						5 – 8.9	Ecotone	1
							Sand	1
23	Oppossum Bay	-42.9901	147.4018			5 – 8.9	Sand	2
24	Blackmans Bay Blowhole	-42.9984	147.3297	5	4	Intertidal	Reef	2
						0 – 1	Reef	3
						1.1 – 4.9	Reef	2
						5 – 8.9	Ecotone	1
							Sand	1
25	Blackmans Bay South	-43.0118	147.3311	5	4			
26	Lucas Point*	-43.0383	147.3389	5	4			
27	Pearsons Point*	-43.0534	147.3421	5	4			

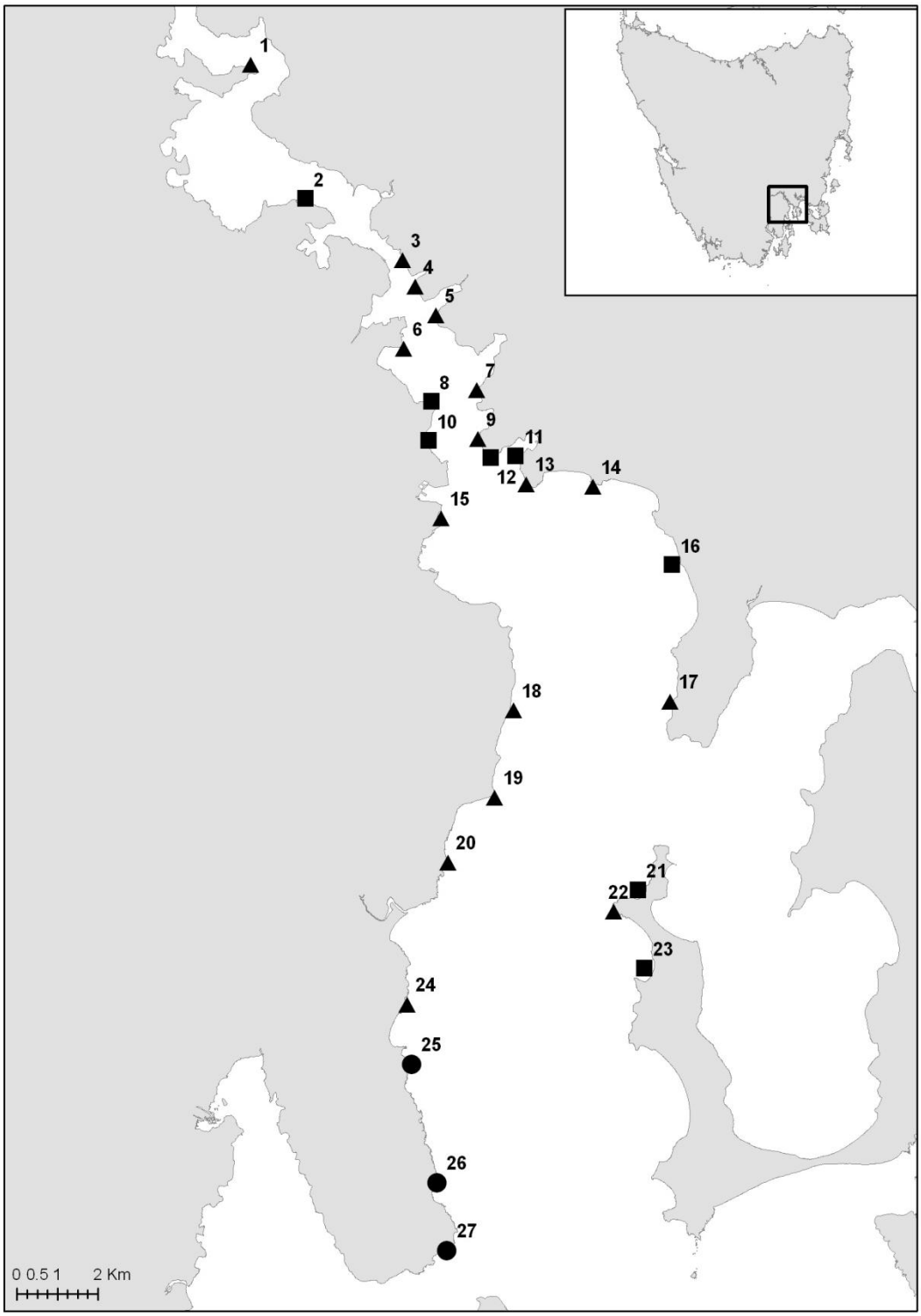

Figure 1. General map showing location of sites surveyed in the Derwent in February-April 2010. ●, standard surveys; ■, timed surveys; ▲, standard and timed species surveys. Sites 26 and 27 were surveyed in March 2009.

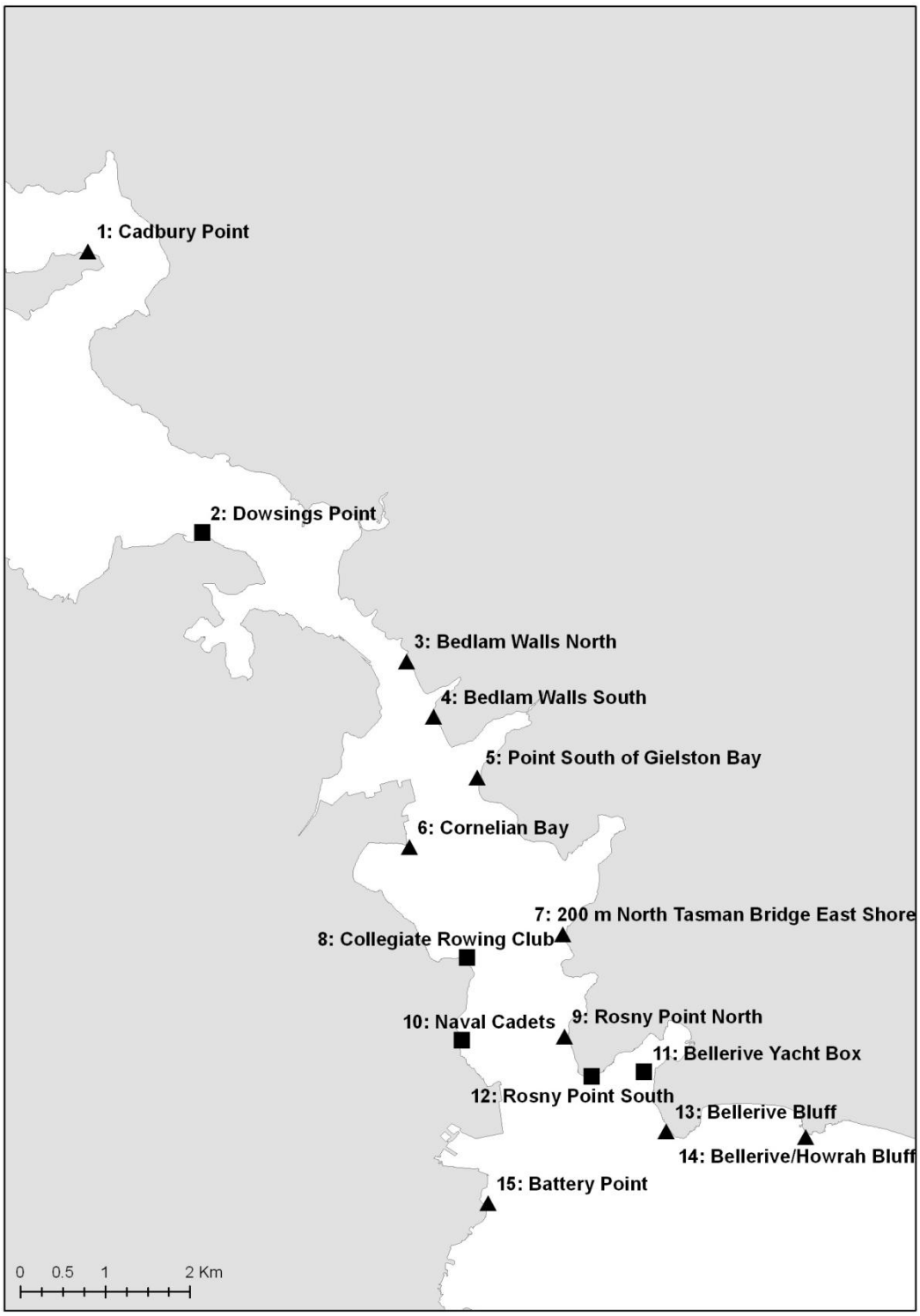

Figure 2. Detailed map showing site positions surveyed in the northern Derwent in February-April 2010. ▲, standard and timed surveys; ■, timed surveys.

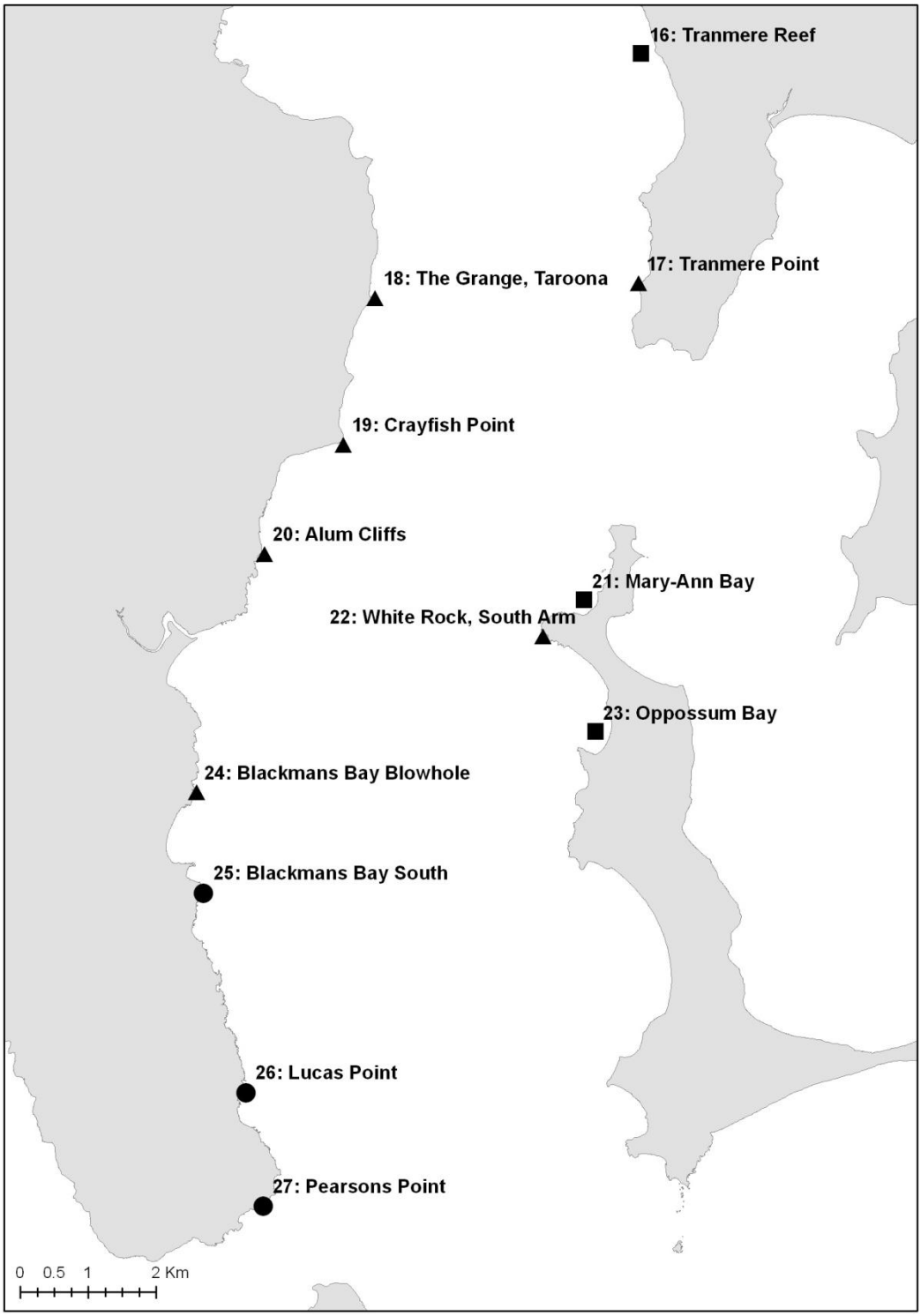

Figure 3. Detailed map showing site positions surveyed in the southern Derwent in February-April 2010. ▲, standard and timed surveys; ●, standard surveys; ■, timed surveys. Sites 26 and 27 were surveyed in March 2009.

3. Results

An extensive dataset was established as a result of the large number of sites surveyed in this study, combined with the two main quantitative methods used. The results presented here are essentially a snapshot of the more general patterns observed between sites along the Derwent estuary using two different survey methods within the time-frame of this study. The more detailed data of the biota recorded within each site, depth and habitat are presented in appendices 1 to 3 (standard surveys) and 4 to 6 (timed surveys), and images of many of the reference species can be found in the attached DVD as appendix 7.

3.1 Standard subtidal surveys

Fish

Fifty four species of fish were counted during the Derwent standard surveys (Appendix 1). The mean diversity of fish species generally increased from northern to southern-most sites within the estuary (Fig. 4). Sites 1 (Cadbury Point), 5 (Point South of Gielston Bay), 6 (Cornelian Bay) and 9 (Rosny Point North; Fig. 2) had the smallest mean number of fish species (2 – 4 species). Sites 18 (The Grange, Taroona), 20 (Alum Cliffs), 24 (Blackmans Bay Blowhole) and 27 (Pearsons Point; Fig. 3) had the largest diversity (10 – 13 species; Fig. 4).

The schooling site resident planktivore *Trachinops caudimaculatus* (Hulafish) was the most abundant fish species and occurred at most sites. Its greatest mean abundances were observed at the northern sites 3 (Bedlam Walls North) and 4 (Bedlam Walls South) with about 1500 individuals per transect, gradually decreasing in abundance south of Gielston Bay to less than 250 individuals per transect (Fig. 5j). *Latridopsis forsteri* (Bastard trumpeter), *Dinolestes lewini* (Long-fin pike), *Notolabrus tetricus* (Blue-throat wrasse) and *Acanthaluteres vittiger* (Toothbrush leatherjacket) were also abundant, especially towards the southern sites of the estuary (Fig. 5). The introduced species *Fosterygion varium* (Many-rayed threefin) and *Grahamina gymnota* (Estuarine threefin), the native *Parablennius tasmanianus* (Tasmanian blenny) and *Favonigobius lateralis* (Long-finned goby) were more abundant in northern parts of the estuary where small-bodied fishes dominated, whilst *Neoodax balteatus* (Little rock whiting) had no clear pattern of distribution (Fig. 5) but was absent from the uppermost sites.

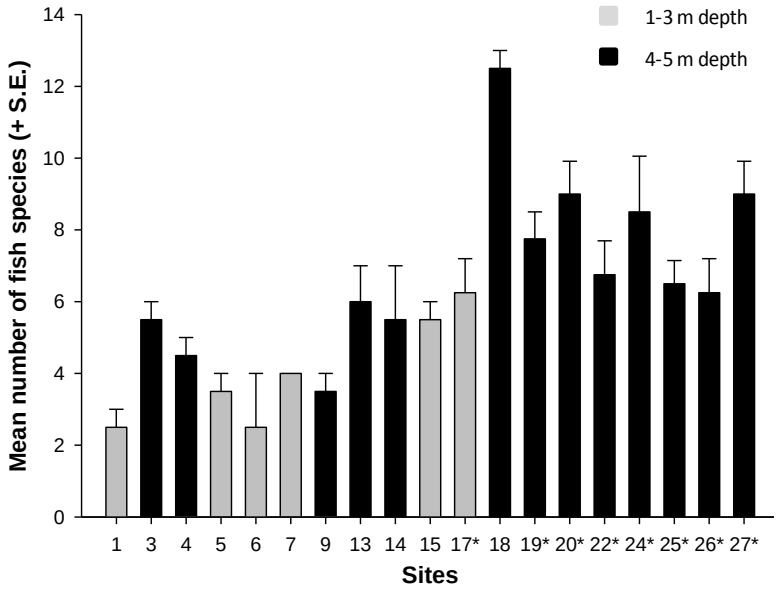

Figure 4. Mean diversity of fish species per transect (500 m^2) in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

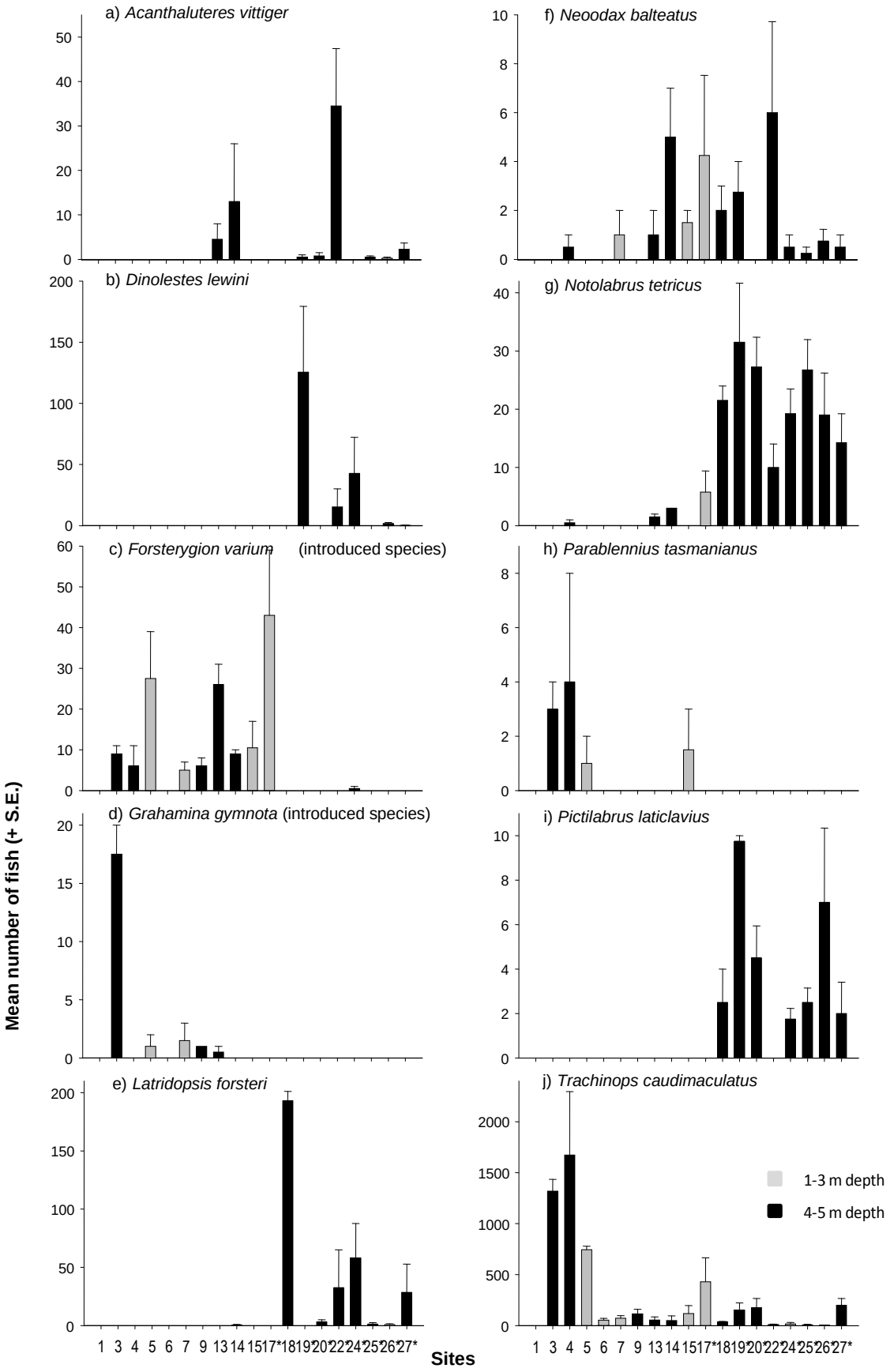

Figure 5. Mean densities of the most abundant fish per transect (500 m^2) in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

Cryptic fish and mobile macro-invertebrates

Fifteen species of cryptic fishes and thirty five mobile macro-invertebrates were counted during the Derwent standard surveys. Macro-invertebrates comprised 11 species of crustaceans, 14 species of echinoderms and 10 molluscs (Appendix 2).

In general the mean diversity of cryptic fish was evenly distributed between sites, with approximately two to three species per transect. Sites such as 7 (200 m North Tasman Bridge), 9 (Rosny Point North) and 13 (Bellerive Bluff; Fig. 2), however, had larger diversities of approximately four to six species per transect (Fig. 6a). The mean abundance of cryptic fish had a similar pattern, with greater numbers of cryptic fish towards the middle sections of the estuary (Fig. 6b). This pattern was primarily driven by the introduced species *Fosterygion varium* (Many-rayed threefin), which was the most abundant cryptic fish (up to 25 individuals per transect, Fig. 7a) and *Grahamina gymnota* (Estuarine threefin). Several species of gobies were also abundant in northern and central parts of the estuary and not observed in the southern-most sites (Fig. 7b). The Southern rock cod, *Scorpaena papillosa* was more abundant in southern parts of the estuary, particularly site 24 (Blackmans Bay Blowhole; Figs 3, 7c). The Common threefin *Trinorfolkia clarkei* was present in approximately 50% of sites sampled, with no clear pattern of distribution (Fig. 7d).

The mean diversity of mobile macro-invertebrate species generally increased from northern to southern-most sites within the estuary. Sites 1 (Cadbury Point) and 9 (Rosny Point North) had lowest diversity (1 – 2 species), whereas sites 24 (Blackmans Bay Blowhole) and 25 (Blackmans Bay South; Fig. 3) had highest diversity (8 – 10 species; Fig. 8).

The most abundant invertebrate was the introduced echinoderm *Patiriella regularis* (Regular seastar), which was more abundant in northern parts of the estuary and reached mean abundances of 200 to 250 individuals per transect at sites 9 (Rosny Point North) and 15 (Battery Point). It was not observed south of site 17 (Tranmere Point; Figs. 2, 9h) where it was essentially replaced by *M. calcar* (Eight-armed seastar) (Fig. 9j). Another introduced species *Asterias amurensis* (Northern Pacific seastar) had a similar pattern, with its largest mean abundance of 14 individuals per transect at Battery Point (Figs. 2, 9d). Other introduced species with smaller abundances (1 – 10 individuals per transect) but restricted to northern-most sites were *Metacarcinus novaezelandiae* (Piecrust crab) and *Petrolisthes elongatus* (New Zealand porcelain crab; Figs. 9b, c). Native species such as *Comanthus trichoptera* (Orange feather star), *Heliocidaris erythrogramma* (Purple urchin), *Meridiastra calcar* (Eight-armed seastar), *Jasus edwardsii* (Southern rock lobster) and *Turbo undulatus* (Turban shell) were more abundant in the southern part of the estuary (Figs. 9e-g, a, i).

In general, the mean diversity and abundance of introduced cryptic fish and invertebrates was greatest in northern and central parts of the estuary than southern sites where introduced species were rare (Fig. 10).

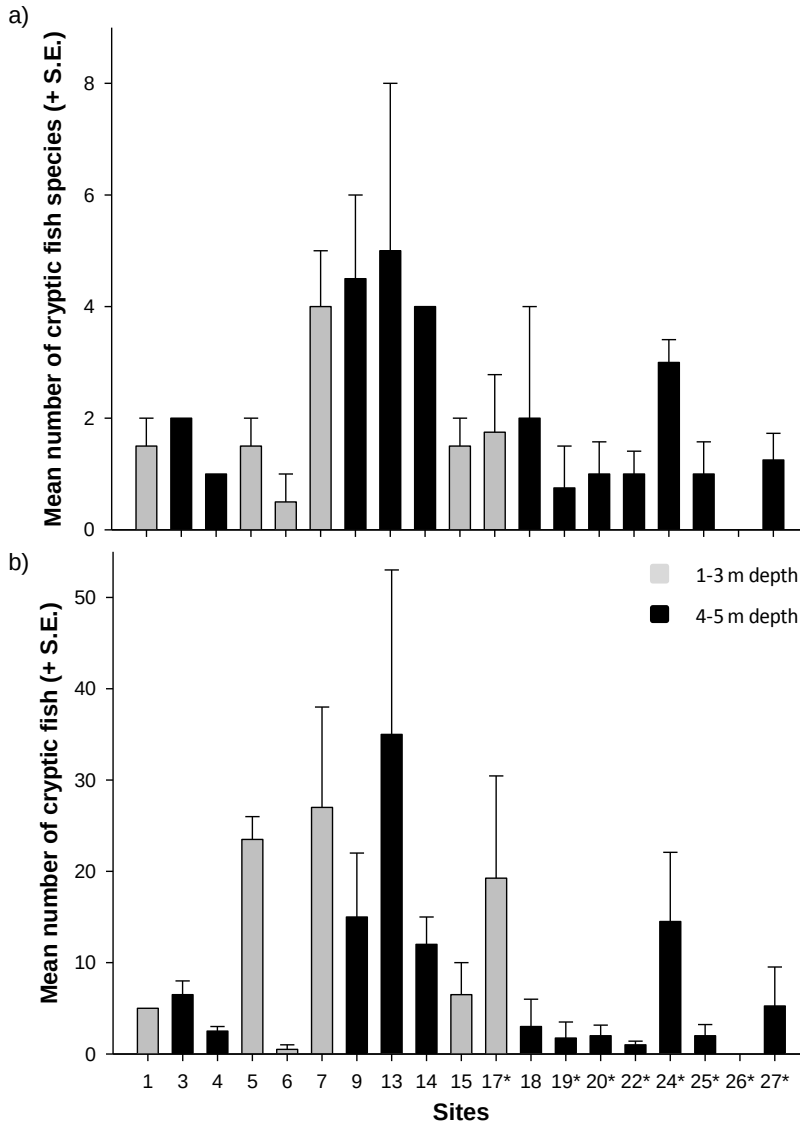

Figure 6. Mean diversity (a) and abundance (b) of cryptic fish in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

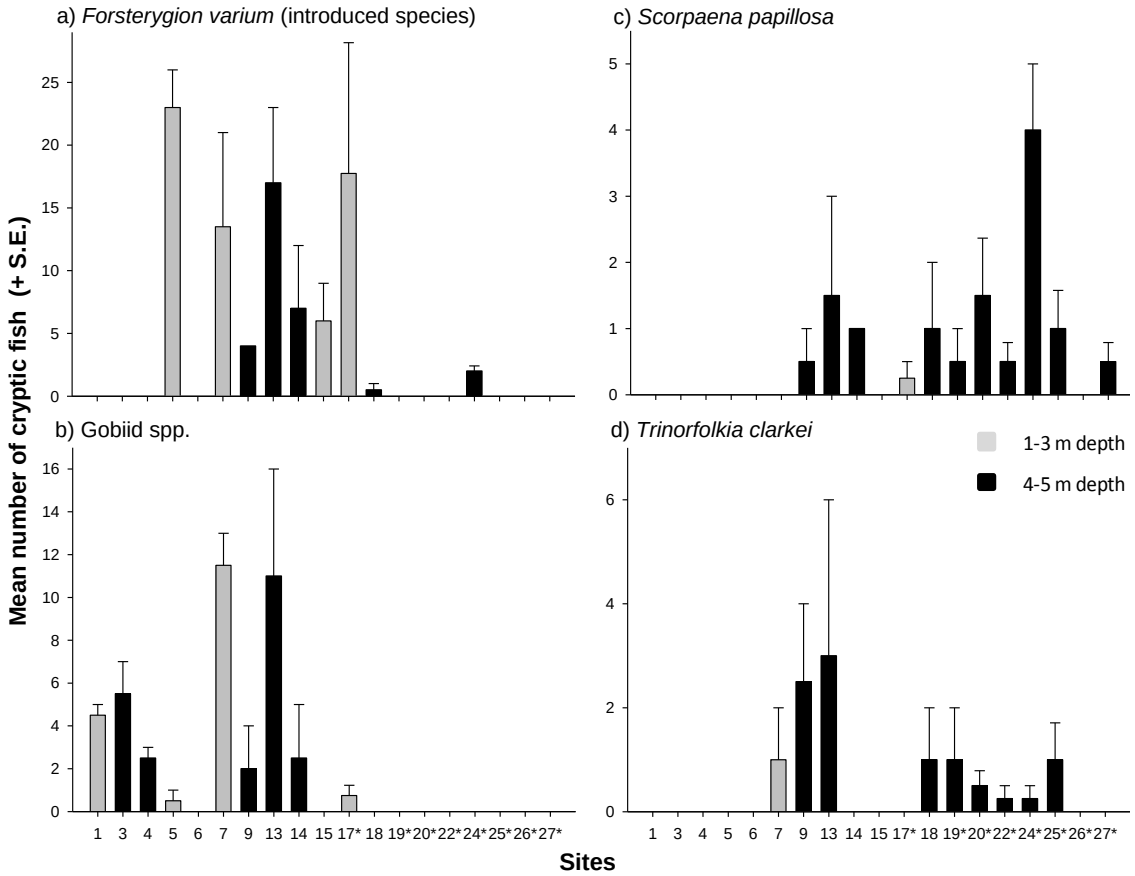

Figure 7. Mean densities of the most abundant cryptic fish in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

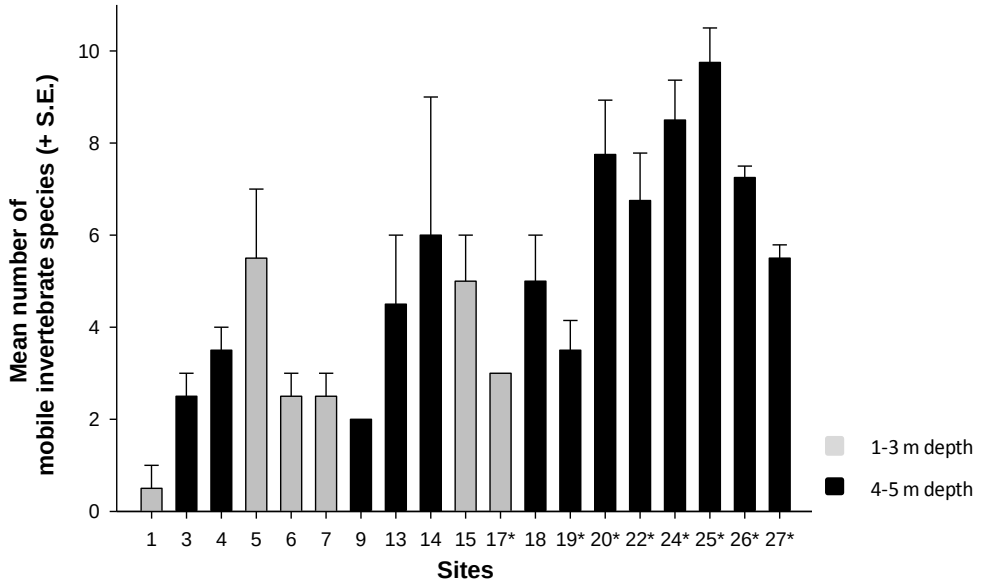

Figure 8. Mean diversity of mobile invertebrates in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

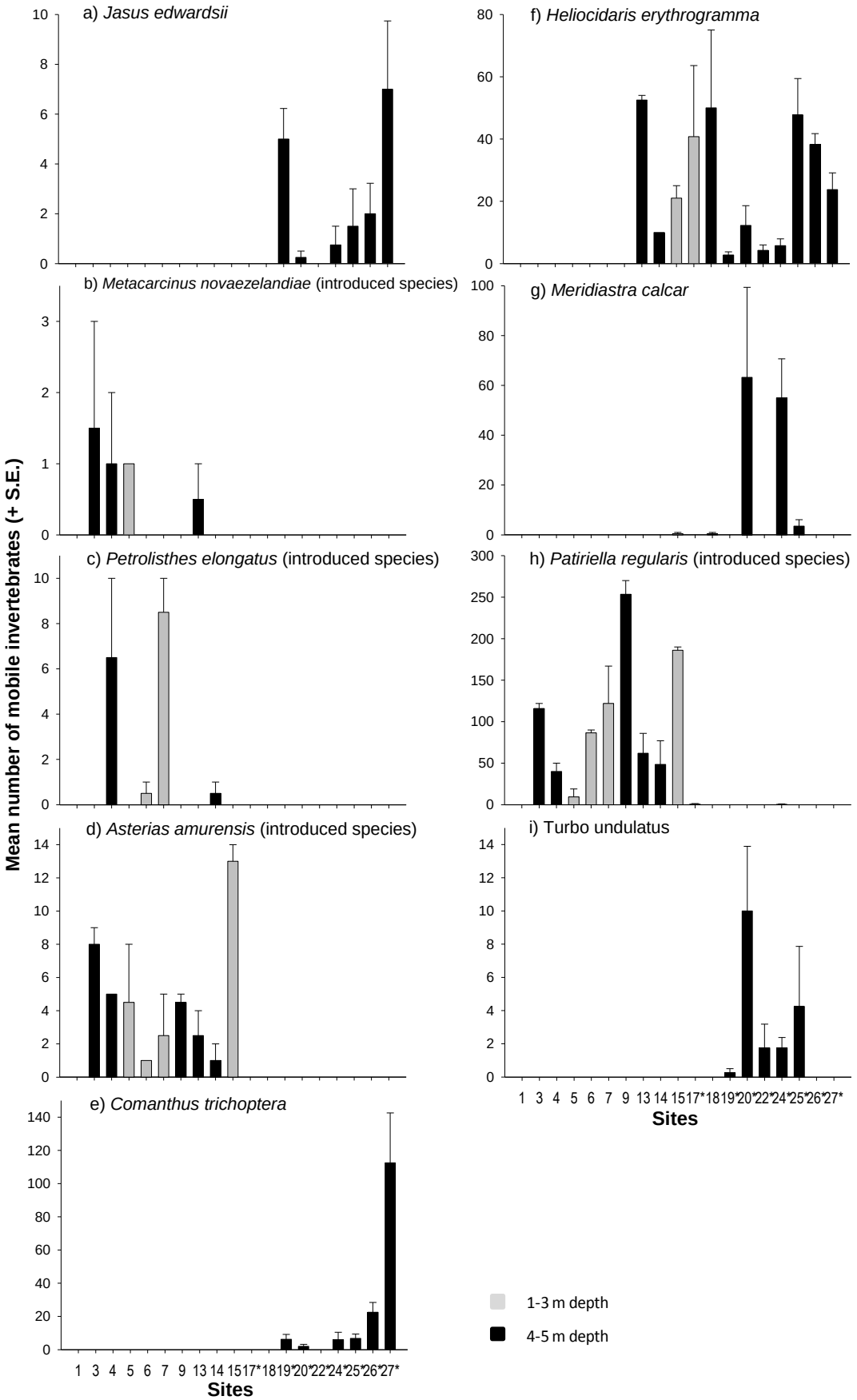

Figure 9. Mean densities of the most abundant mobile crustaceans (a–c), echinoderms (d–h) and molluscs (i) in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

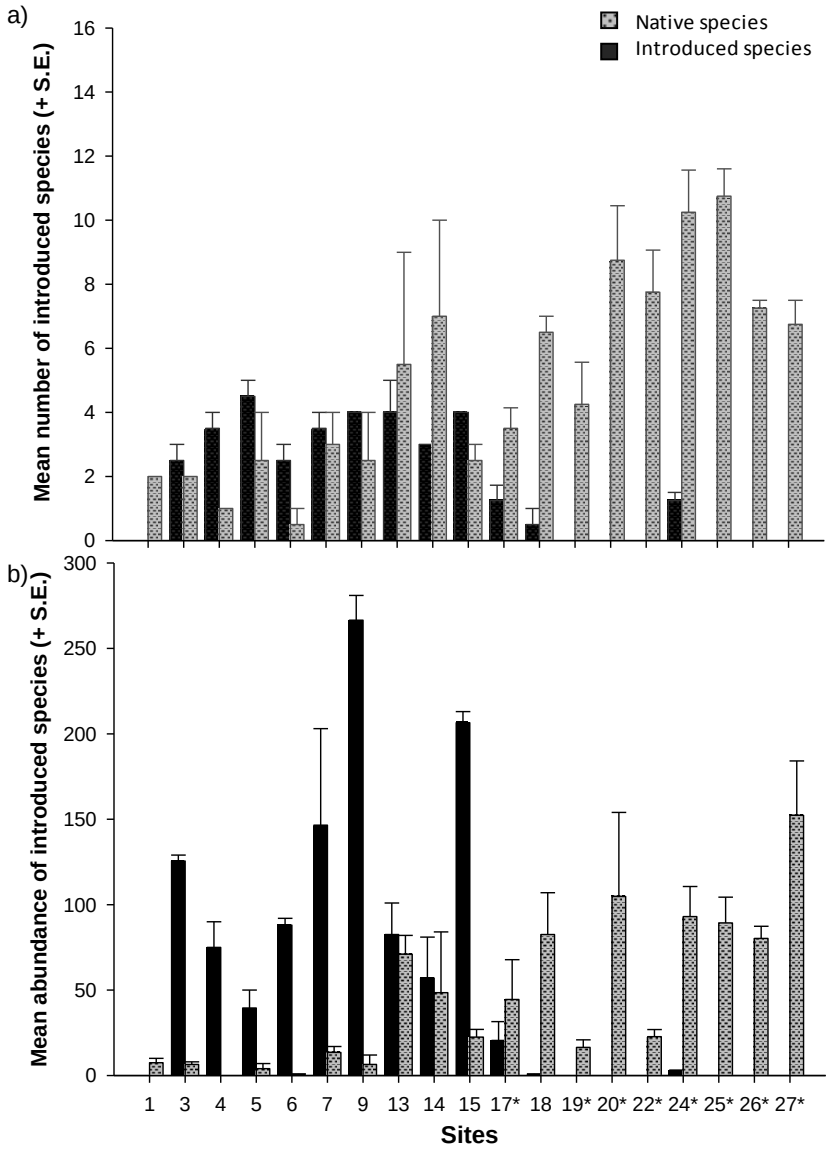

Figure 10. Mean diversity (a) and abundance (b) of cryptic fish and mobile invertebrates in the Derwent showing native (grey) introduced (black).species. Two transects or four transects (*) were surveyed at each site.

Algae and sessile invertebrates

Over seventy-two species of algae and twenty one sessile invertebrates were sampled during the Derwent standard surveys. While more species were present, identifications were restricted to species or genus that could be identified in the field. Algae comprised 21 species of brown algae, 9 species of green algae and 42 species of red algae (Appendix 3).

Mean values of diversity and percentage cover of all algae were considerably greater in southern than northern parts of the estuary. The largest diversity and algal cover were found between sites 19 (Crayfish Point) and 27 (Pearsons Point; Fig. 3) with a mean number of up to 20 species of algae per transect (Fig. 11). This pattern was even more pronounced for the foliose algal species, as these were generally absent from many northern sites of the estuary such as sites 3 (Bedlam Walls North) to 6 (Cornelian Bay; Figs. 2, 12). Overall, the mean percentage cover of brown, green and foliose red algae was considerably greater towards

southern parts of the estuary (Figs. 13a-c). Sessile invertebrates however covered similar areas in most sites, with slightly greater areas covered in northern parts of the estuary (Fig. 13d), but with a marked shift in the species composition of invertebrate cover along the estuary (Fig. 16.).

Brown algae, when present (essentially south of Rosny Point), usually provided a significant proportion of total cover, and included *Ecklonia radiata*, *Lessonia corrugata*, *Carpoglossum confluens, Acrocarpia paniculata, Sargassum fallax* and the introduced species *Undaria pinnatifida* (Fig. 14). *Undaria* was found only at sites 18 (The Grange, Taroona) to 20 (Alum Cliffs) and 25 (Blackmans Bay South; Figs. 3, 14). *Macrocystis pyrifera*, a species of particular conservation interest, was present from the Blackmans Bay Blowhole and at sites further south along the western shore, and was particularly abundant at site 25, forming 18% of the benthic cover. This is probably a significant under-estimate of total cover as much of the *Macrocystis* canopy floats near the sea surface and so is not measured by the quadrat methodology used here.

The most common red algae present were encrusting *Peyssonnelia spp*, crustose coralline algae, and *Jeannerettia lobata* (Figs. 15b-d). Generally filamentous red algae dominated the northern part of the estuary (Fig. 15e), although the foliose red *Gracilaria ramulosa* was common at the Cadbury Point. *Aeodes nitidissima,* a species inferred to be introduced, was found at only sites 7 (200 m North of Tasman Bridge) to 14 (Bellerive/Howrah Bluff. Figs. 2, 15a), where it was locally abundant, forming up to 10% of total cover.

Most substrata in northern parts of the estuary were covered by a polychaete tube-worm matting (Fig. 16e) and oysters (*Crassostrea gigas*) (Fig. 16a). The tube-worm matting usually formed a significant proportion of the overall cover where present, and trapped fine silty sediments to form a thick (2-3 mm) fibrous matting. Initial examination of the material suggests the matting is produced by a polychaete in the family Spionidae, possibly a *Polydora* species based on size of the animal and arrangement of feeding tentacles. Other common sessile invertebrates were sponges, particularly encrusting sponges, the oyster *Ostrea angasi*, the blue mussel *Mytilus galloprovincialis* and ascidian *Pyura gibbosa*, all of which had greater cover in southern than northern-parts of the estuary (Fig. 16). A clear geographical disjunction was evident between the encrusting tube-worm matting and the cover of encrusting sponges and encrusting coralline algae, presumably based on the extent of sedimentation on the reefs. The major ecological change was centred between Rosny Point and Bellerive Bluff. The native oyster *Ostrea angasi* was particularly common at White Rock, where it formed more than 10% of the overall cover.

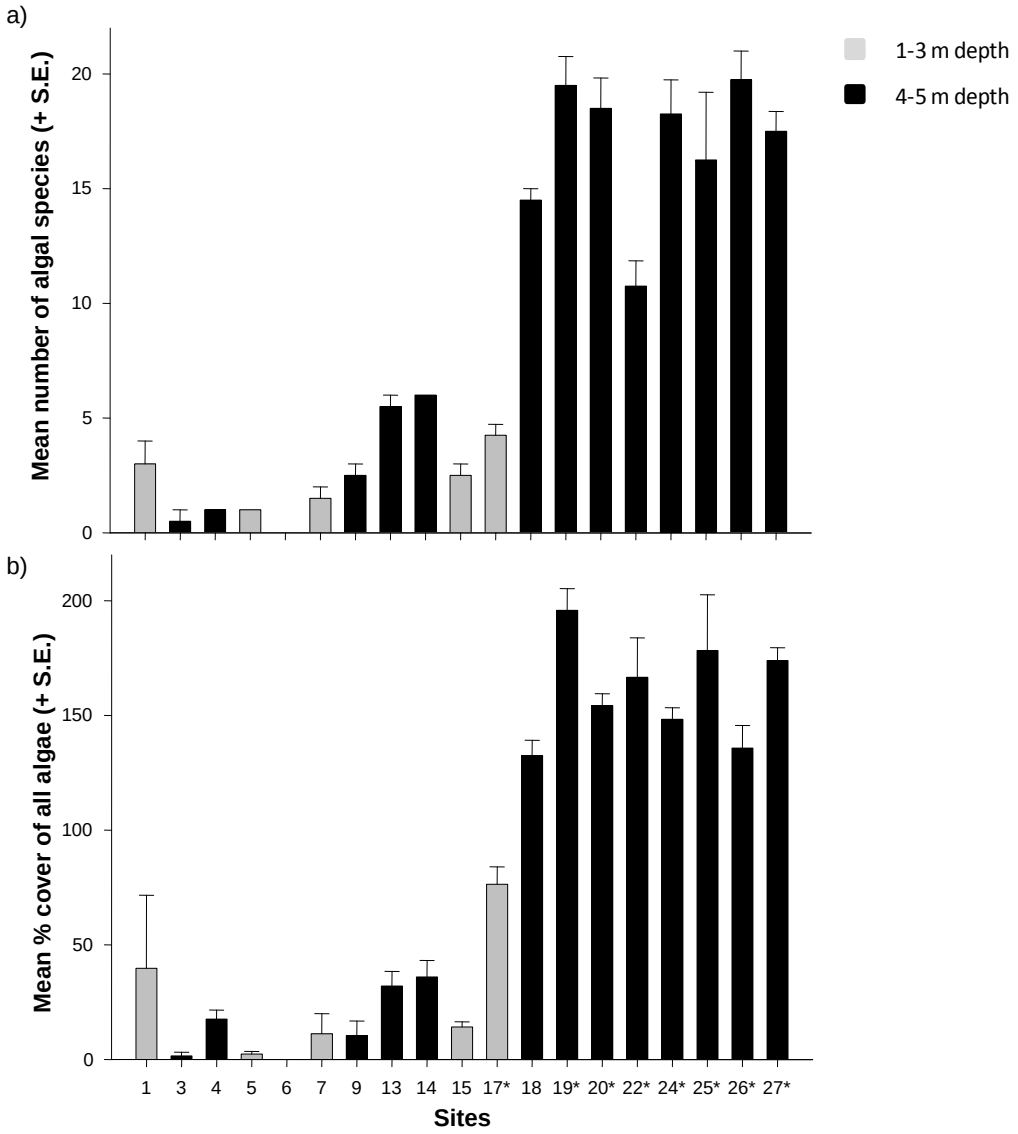

Figure 11. Mean diversity (a) and percentage cover (b) of algae in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site. Percentage cover includes understory and canopy forming algae so cover may exceed 100 %.

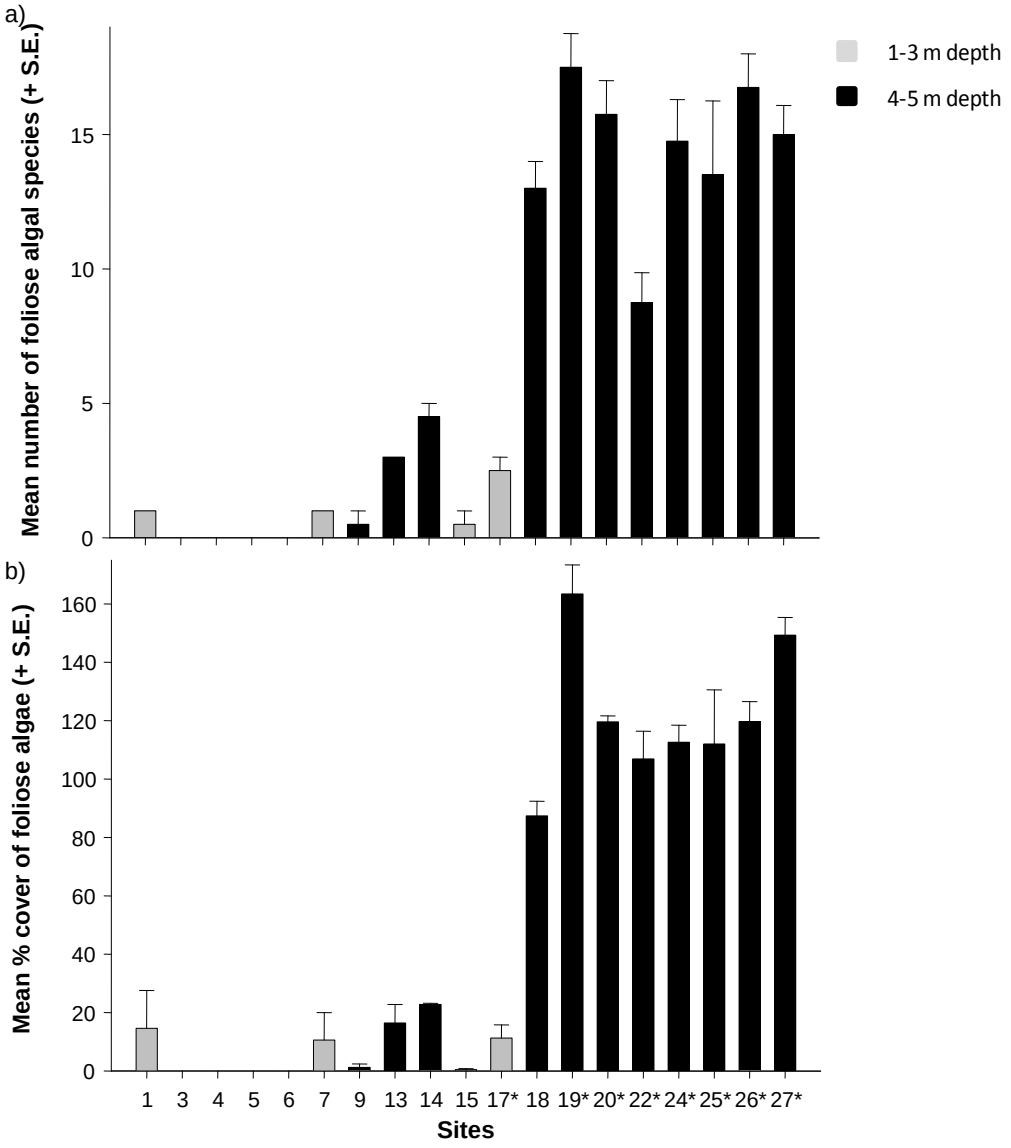

Figure 12. Mean diversity (a) and percentage cover (b) of foliose algae in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site. Percentage cover includes understory and canopy forming algae so cover may exceed 100 %.

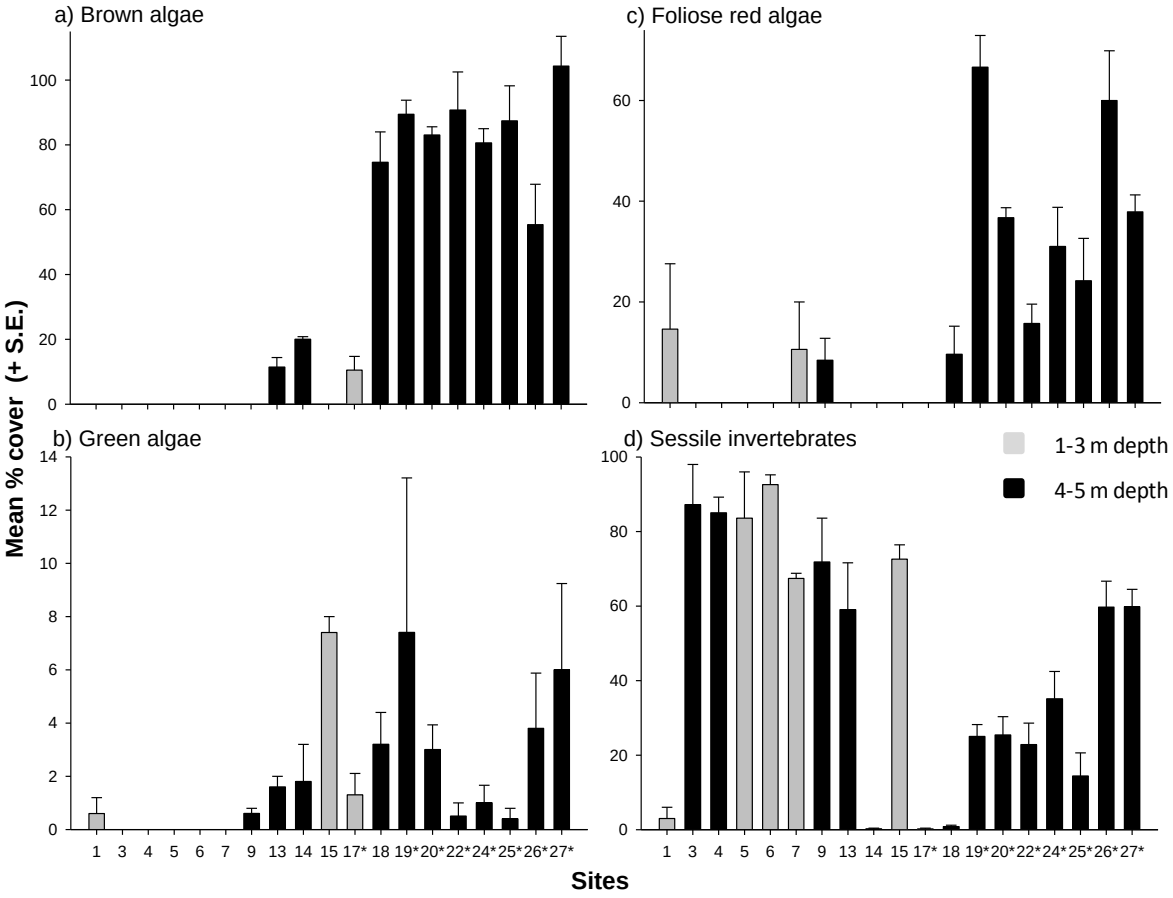

Figure 13. Mean percentage cover of brown (a), green (b) foliose red (c) algae and sessile invertebrates (d) in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

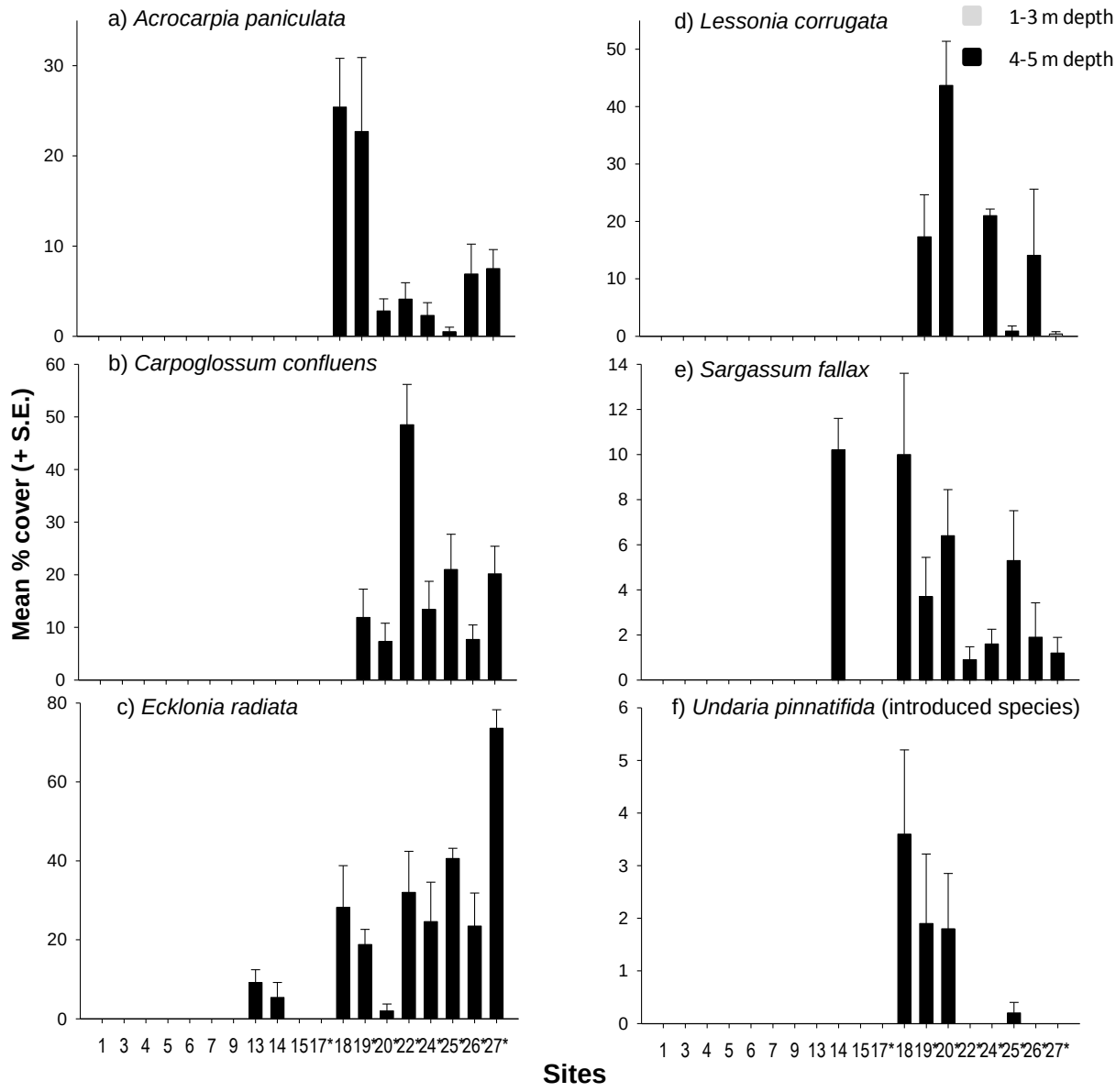

Figure 14. Mean percentage cover of the most abundant brown algae in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

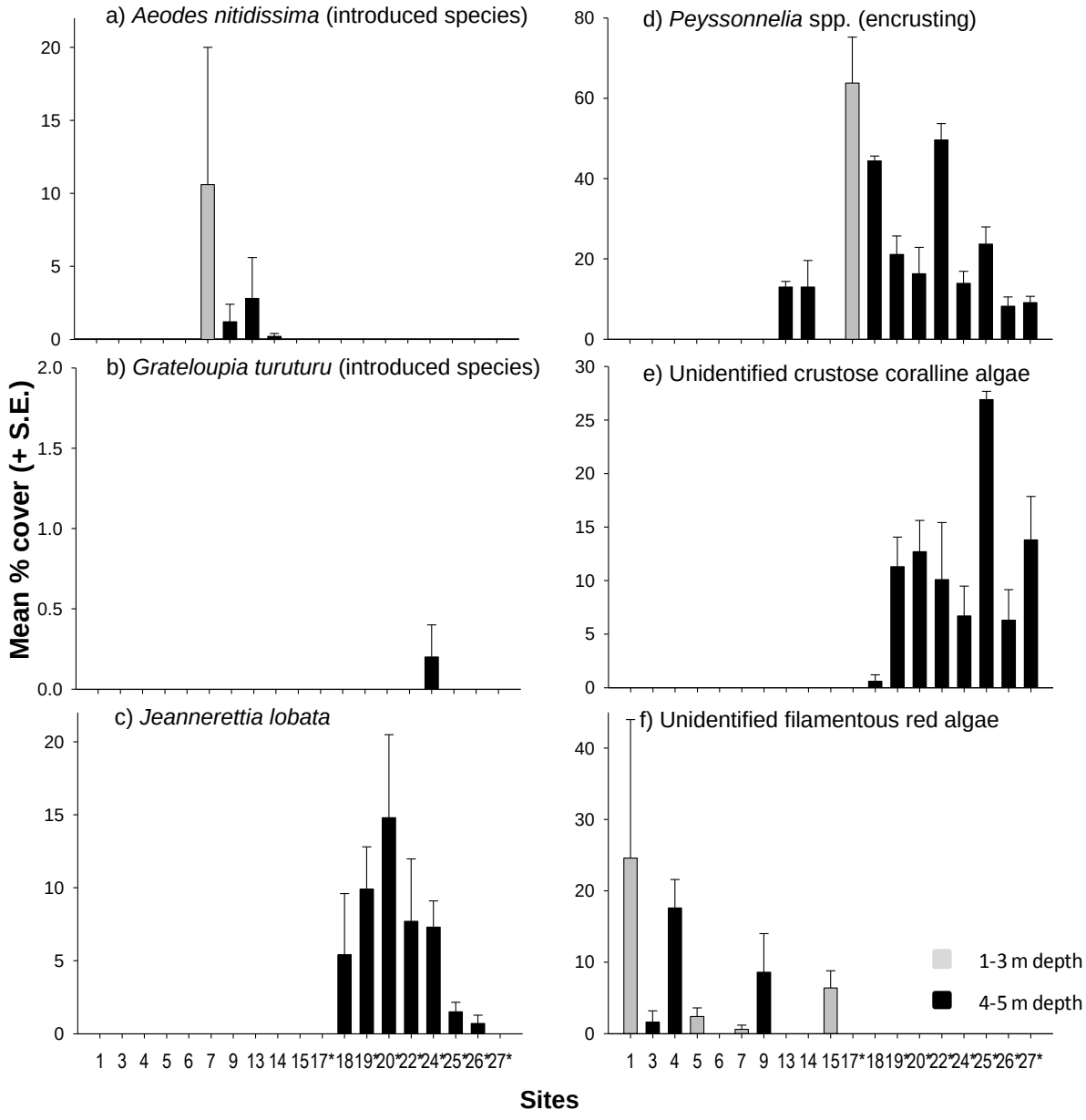

Figure 15. Mean percentage cover of the most abundant and introduced red algae in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

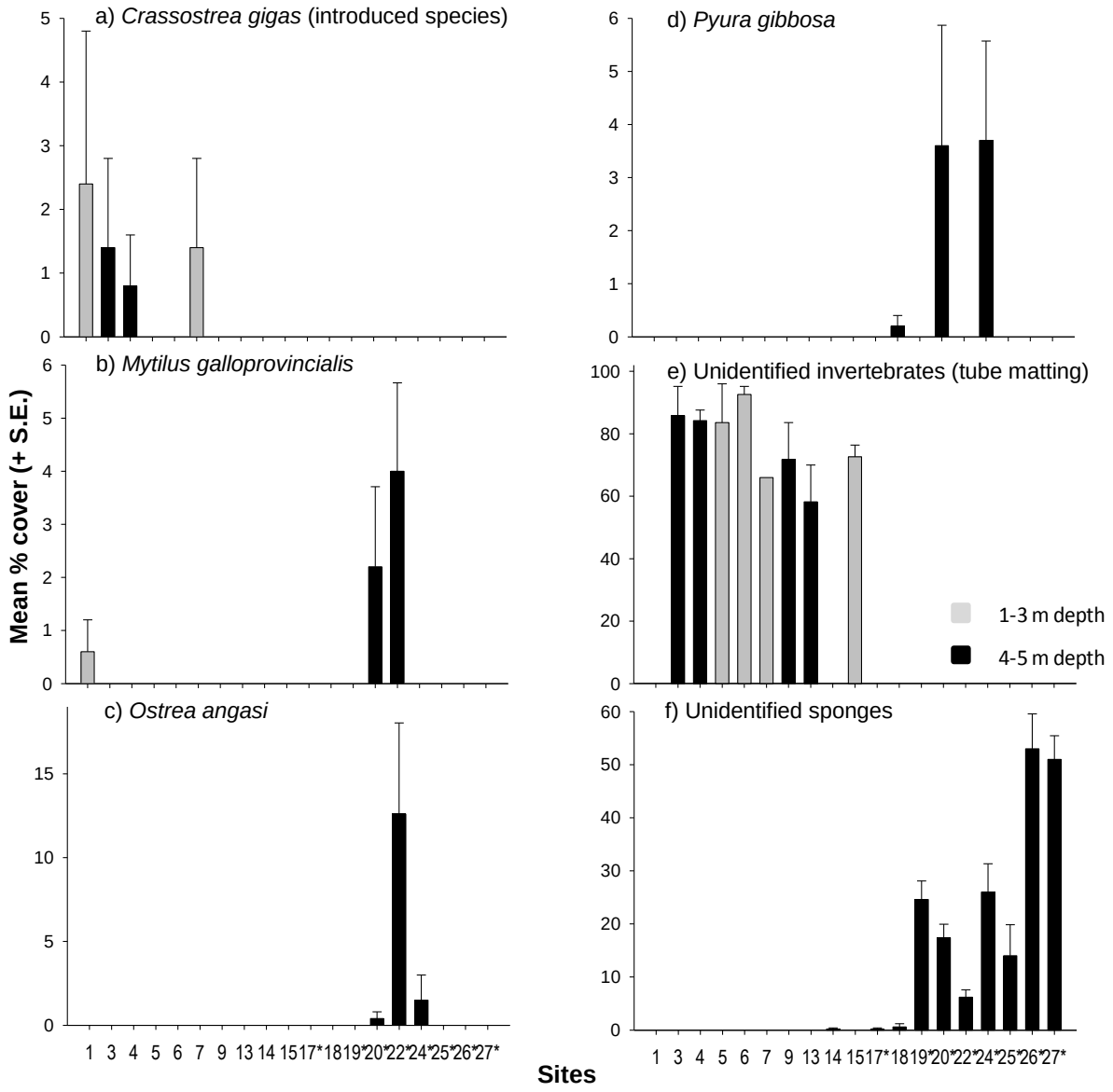

Figure 16. Mean percentage cover of the most abundant sessile invertebrates in the Derwent at 1-3 m (grey) and 4-5 m depths (black). Two or four (*) transect blocks were surveyed at each site.

3.2 Timed intertidal and subtidal surveys

General patterns

Overall, the species richness of fish, invertebrates and algal species appeared to be relatively evenly distributed across the different depths and habitats sampled, other than a general trend for lower species richness in sand habitats (Fig. 17). However, the mean number of species found in each search increased markedly from northern to southernmost sites within the estuary, particularly within the searches on reef at 1-4.9 m depth. Species richness generally doubled along the estuarine gradient, with a marked jump in numbers seaward of Rosny Point (Fig. 17).

For introduced species, the overall species richness was relatively evenly distributed across different habitats and depths, with generally two to three introduced species found at each site sampled (Fig. 18). Sites sampled at 0 – 0.9 m depths were an exception, with greater numbers of introduced species (2 – 3) found in sites sampled in middle parts of the estuary than northern and southern sites (which had only 1 introduced species; Fig. 18b).

Rarely encountered species (defined here as species recorded as only a single individual at any one site) were unevenly distributed across different habitats and depths, with a tendency to increase towards the southern end of the estuary at 1– 8.9 m depths (Fig. 19). Subtidal reef habitats to 0.9 m depth had the smallest number of rare species (up to 5 species), whilst subtidal reefs with depths from 5-8.9 m had the largest number of rare species (up to 10 species represented by only a single individual; Fig. 19). A slightly greater number of rare species of fish, invertebrates and algae were found in sandy habitats than in reef and ecotone (sand-reef) habitats (Fig. 20a-d). Common (most abundant) species of fish, invertebrates and algae were more diverse in reef habitats than in sand and ecotone (Fig. 20a-d). Introduced species had similar abundance scores across different habitats (Fig. 20e). No clear patterns of diversity across different depths for common and rare species of fish, invertebrates and algae were found (Fig. 21a-d). Introduced species had similar abundance scores across different depths (Fig. 20e).

Target Rare Species

The presence of the rare and threatened Derwent river seastar, *Marginaster littoralis*, was not detected at any of the sites, depths and habitats sampled, despite the extensive intertidal and subtidal search effort. At the Cornelian Bay location from which *M. littoralis* was described, *Patiriella regularis* (Regular seastar), an introduced species from New Zealand, and *Petrolisthes elongates* (New Zealand Porcelain Crab) were present in large numbers (> 1000 individuals per search) at this site. The timed searches also failed to detect other rare species associated with rocky reef systems and known to occur in areas adjacent to the Derwent estuary (*Parvulastra vivipara* and *Smilasterias tasmaniae*), although search effort was not focussed on these species and their habitats, and neither had previously been described from the Derwent. Timed searches did, however, find the rare and critically endangered Spotted handfish *Brachionichthys hirsutus* between 5 – 8.9 m depths on sand at site 13 (Bellerive Bluff; Fig. 2; Appendix 4), although only one individual was detected.

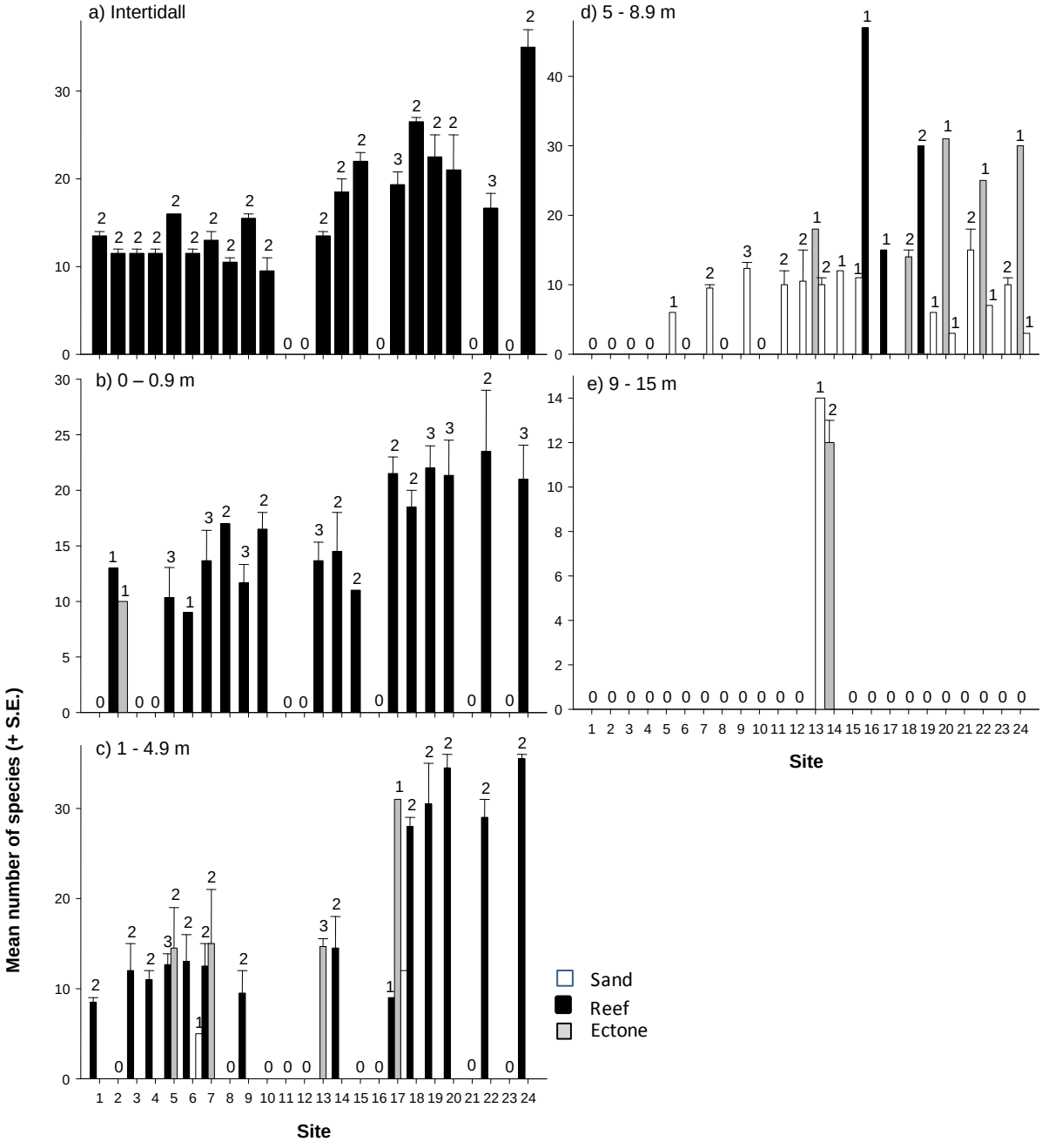

Figure 17. Mean species richness of all fish, invertebrate and algal species recorded during timed swims in the Derwent in reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Numbers of searches undertaken at each site are above each bar.

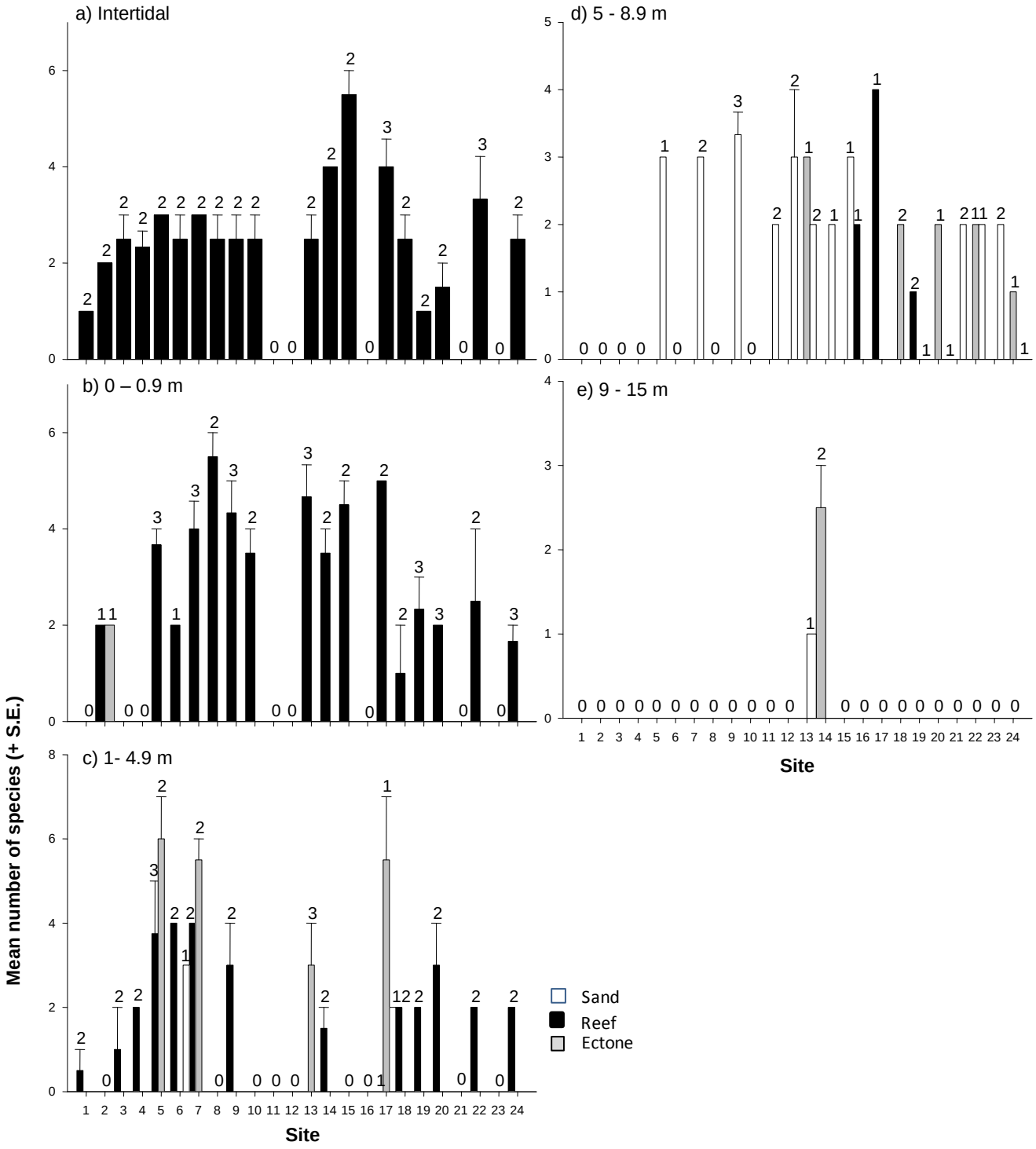

Figure 18. Mean species richness of introduced species recorded during timed swims in the Derwent in reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Numbers of searches undertaken at each site are above each bar.

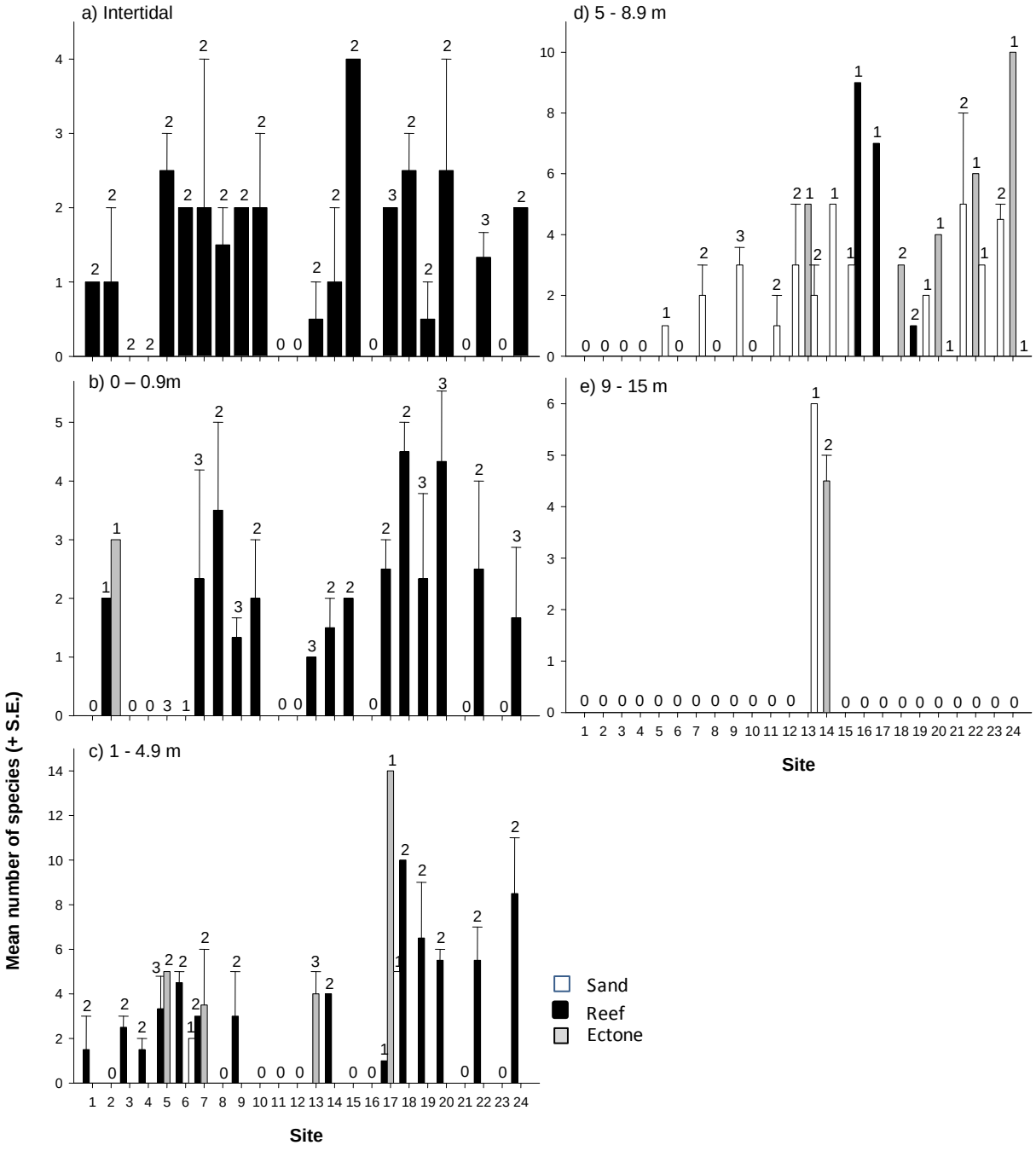

Figure 19. Mean richness of the least abundant species (only 1 found for each species) recorded during timed swims in the Derwent in reef (black), sand (white) and ecotone (reef-sand; grey) habitats at different depths. Numbers of searches undertaken at each site are above each bar.

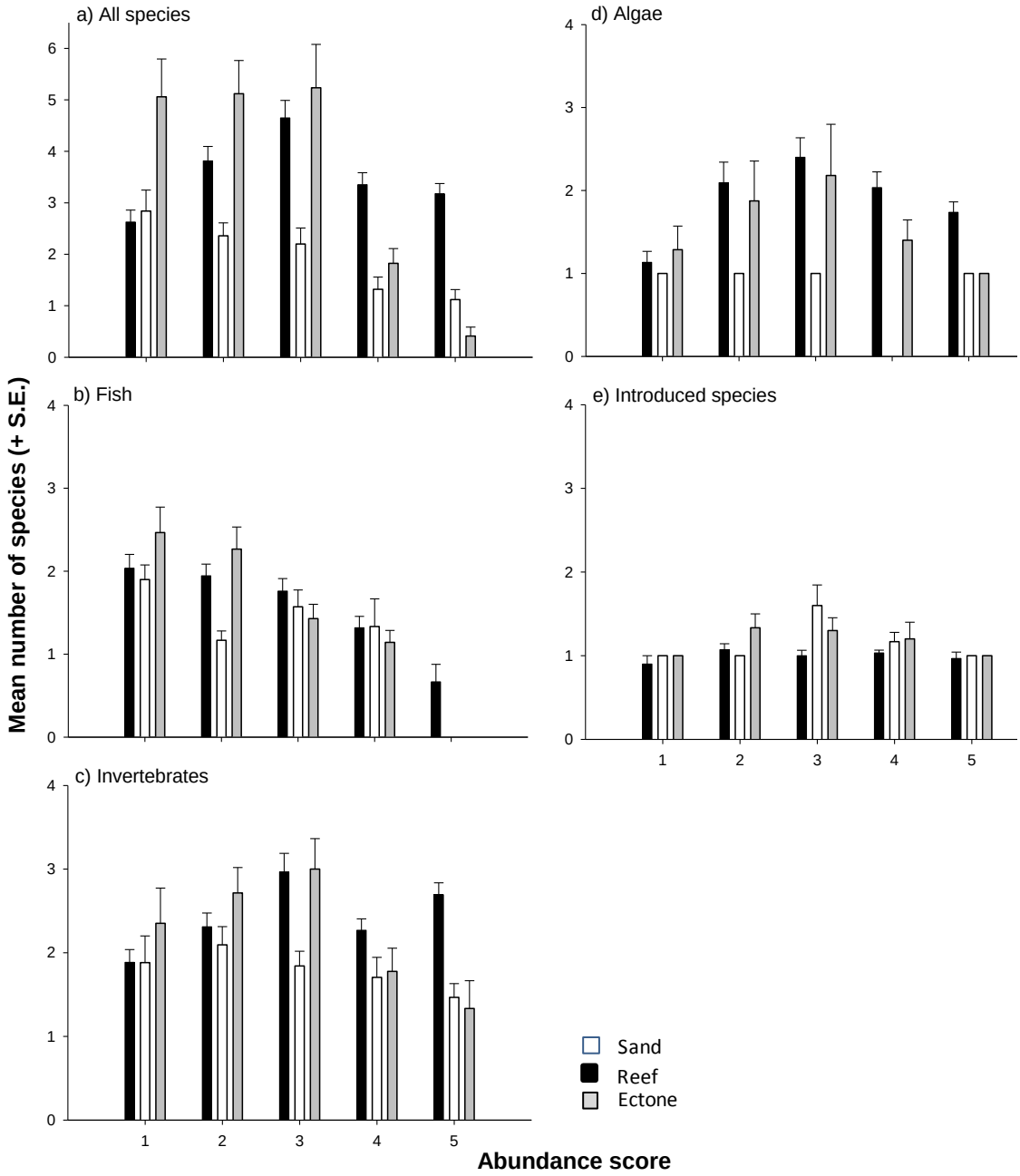

Figure 20. Mean number of species recorded during timed swims in the Derwent across different habitats: reef (black), sand (white) and ecotone (reef-sand; grey). Abundance score 1 = 1 only; 2 = 2–10; 3 = 11–100; 4 = 101–1000; 5 = 1000+. Number of searches undertaken at each site and habitat are in table 1.

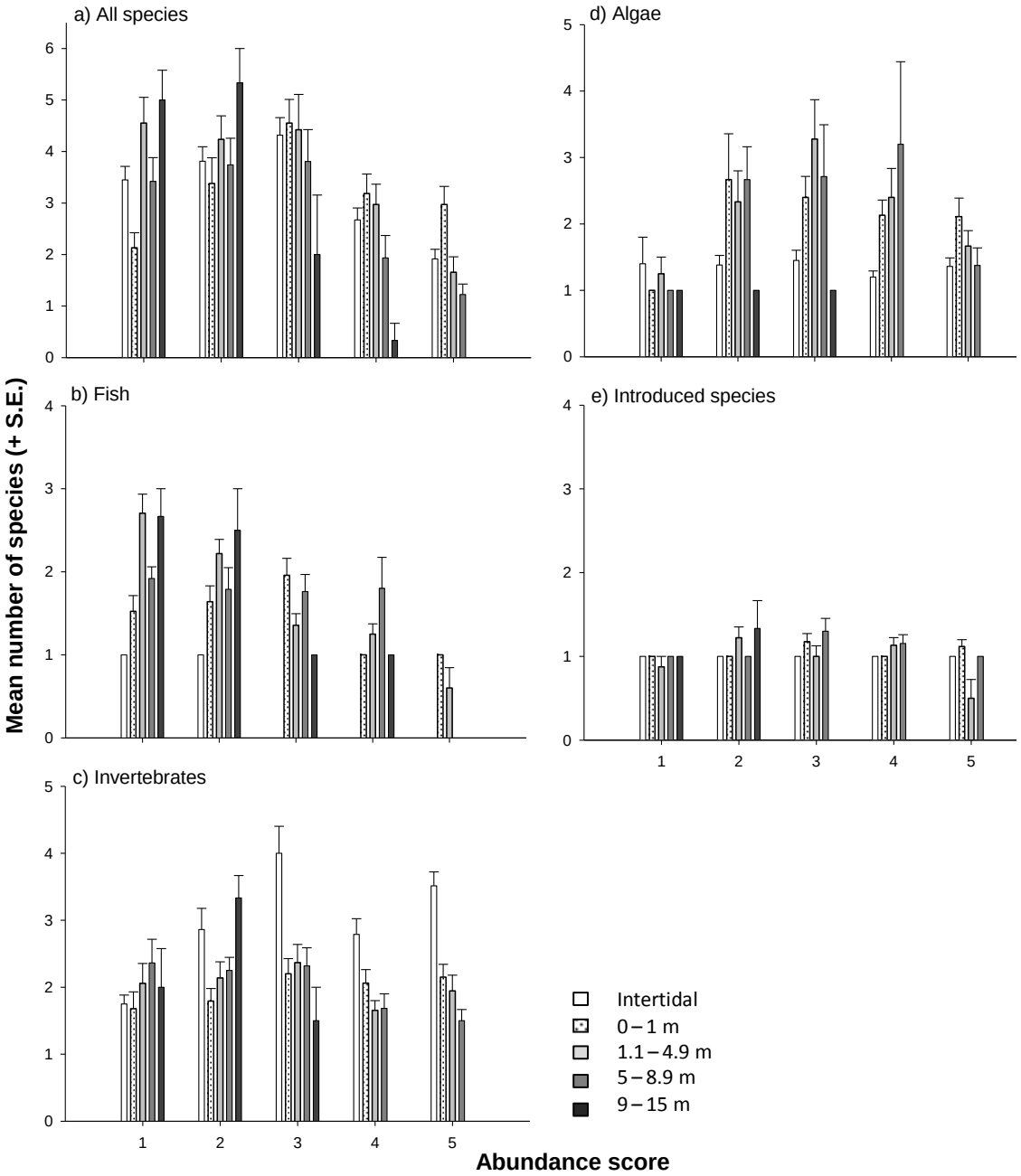

Figure 21. Mean species richness of different taxa recorded during timed swims in the Derwent across different depths. Abundance score 1 = 1 only; 2 = 2–10; 3 = 11–100; 4 = 101–1000; 5 = 1000+. Number of searches undertaken at each site and habitat is shown in table 1.

Fish

Seventy four species of fish were counted during the Derwent timed surveys (Appendix 4). As with standard surveys, with the exception of intertidal habitats and subtidal habitats of 9 - 15 m depths (where only 2 sites were sampled), the mean diversity of fish species generally increased from northern to southern sites within the estuary (Fig. 22). The mean number of fish species varied from two to four species at several northern sites to a maximum of 12 to 14 found at sites 16 (Tranmere Reef) and 19 (Crayfish Point; Figs. 3, 22).

As with standard surveys, *Trachinops caudimaculatus* (Hulafish) was the most abundant fish species in reef and ecotone habitats and was found at most sites, with no clear patterns in rank abundance detected across sites (Fig. 23f). The clearest pattern with respect to spatial distribution related to *Grahamina gymnota* (Estuarine threefin) and *Fosterygion varium* (Many-rayed threefin) (both introduced species) which were strongly associated with the mid-upper sites within the estuary (Figs 23a&b) and were absent from the more southern sites. A similar, but reversed pattern, was shown by many marine species (Appendix 4), such as the normally abundant *Notolabrus tetricus* (Blue-throat wrasse) which was virtually absent upstream from Rosny Point (Fig. 23d). Some common species with no clear patterns of abundance across sites included *Neoodax balteatus* (Little rock whiting) and *Parablennius tasmanianus* (Tasmanian blenny; Figs. 23c,e). Overall the upstream assemblage was characterised and dominated by small bodied fishes such as the gobies and blennies, whereas the downstream assemblages was characterised by far greater diversity, and many more larger bodied fishes such as the wrasses, bastard trumpeter and leatherjackets (Appendix 4). No clear patterns were found with respect to the depth distribution of individual species, potentially at least because not all depth bands are represented at each site. However, there was clear differentiation between reef and soft-sediment associated species, with lower abundances and diversity found in most soft-sediment areas searched. As discussed earlier, one individual spotted handfish was sighted at the Bellerive Bluff site, but no other handfish were sighted at other sites within the known range of this species, despite similar search replication at many of these.

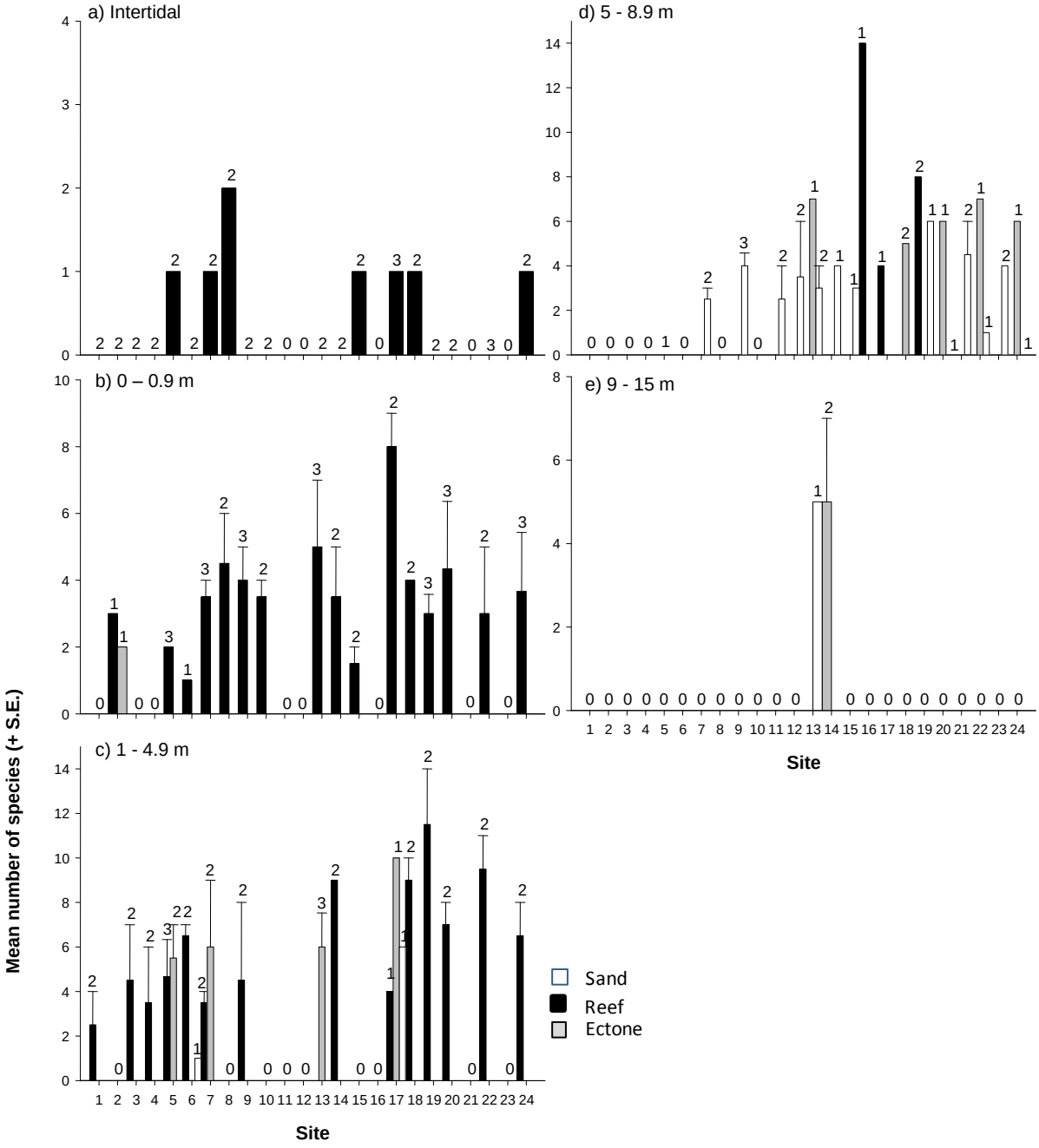

Figure 22. Mean diversity of fish species in the Derwent on reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Numbers of searches undertaken at each site are above each bar.

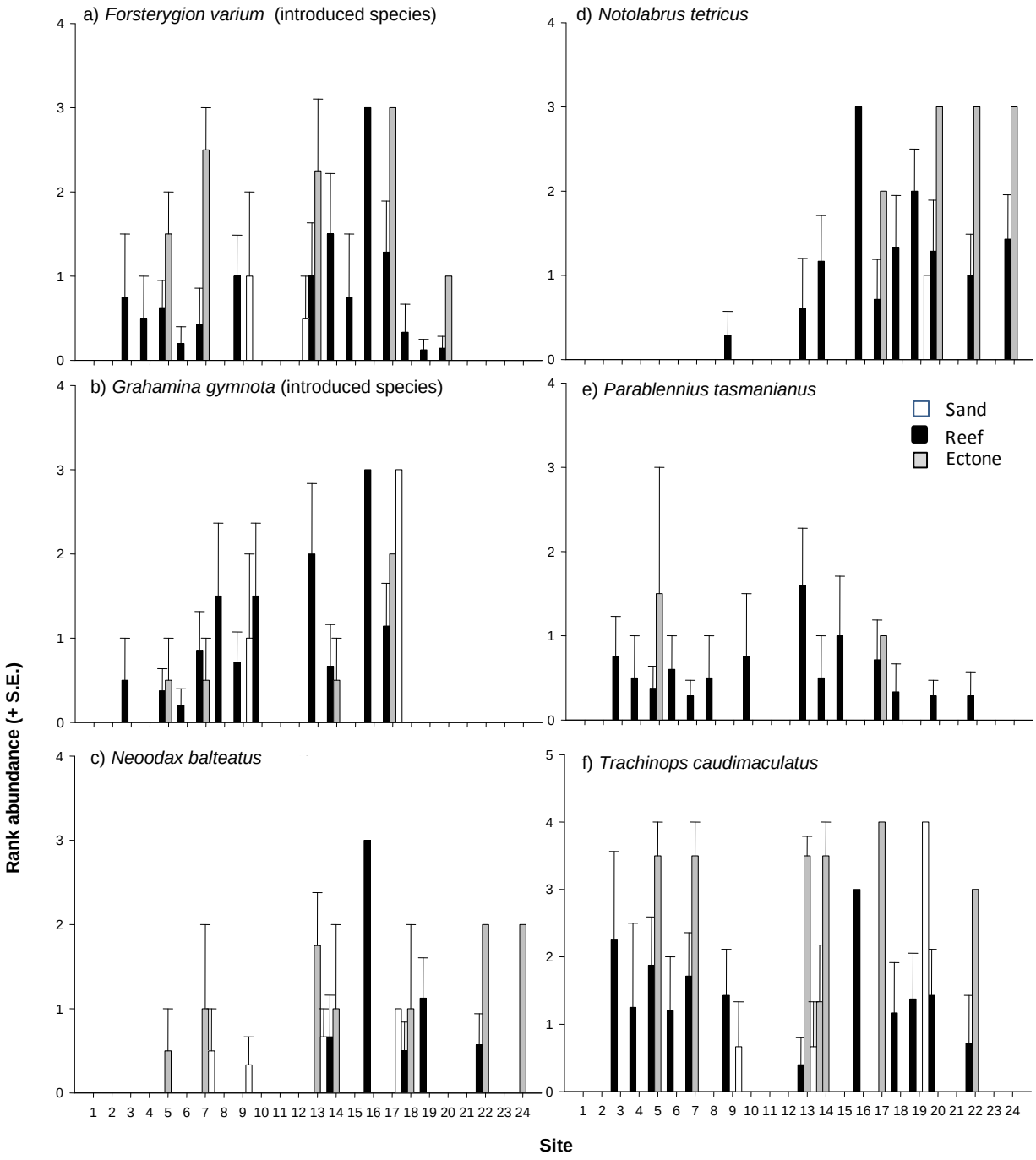

Figure 23. Mean rank abundance of the most abundant fish species in the Derwent on reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Number of searches undertaken at each site and habitat are in table 1.

Macro-invertebrates

One hundred and forty seven species of macro-invertebrates were recorded during the Derwent timed-swim surveys. These comprised by 13 ascidian, 5 barnacle, 10 cnidarian, 30 crustacean, 17 echinoderm, 1 echiuran, 3 flatworm, 58 mollusc and 10 polychaete species (Appendix 5).

As with standard surveys, with the exception of subtidal habitats of 9 – 15 m depths (where only 2 sites were sampled), the mean diversity of macro-invertebrate species generally increased from northern to southern-most sites within the estuary (Fig. 24). The mean number of invertebrate species encountered per search varied from two to five species at several northern sites to a maximum of 12 - 25 found at several southern sites such as sites 22 (White Rock, South Arm) and 24 (Blackmans Bay Blowhole; Figs. 3, 24).

As with standard surveys, the most abundant invertebrates sighted were the introduced echinoderms *Patiriella regularis* (Regular seastar) and *Asterias amurensis* (Northern Pacific seastar), the introduced crustaceans *Petrolisthes elongatus* (New Zealand porcelain crab) and *Metacarcinus novaezelandiae* (Piecrust crab; Fig. 25). Other abundant invertebrates also detected in timed surveys were the blue mussel *Mytilus galloprovincialis,* the introduced *Crassostrea gigas* (Pacific oyster) and introduced fan worm *Myxicola infundibulum* (abundant in sandy habitats; Fig. 25). While as a general rule *A. amurensis* was predominantly restricted to the soft sediments and *P. regularis* to reef and intertidal platforms, *A. amurensis* was occasionally found in large numbers on the reef itself (usually as small juveniles) and *P. regularis* on sediment (although often in poorer condition than nearby reef associated individuals). At many locations in the mid-estuary (Tasman Bridge to the Grange), *P. elongatus* were super-abundant under most rocks able to be turned from the mid-intertidal to the low-water mark, and clearly dominated this habitat. While less abundant than *P. elongatus,* the introduced species *Carcinus maenus* (Green shore crab) was also quite common in the mid to upper sites surveyed within the estuary (Battery Point to Dowsings Point), particularly in the lower intertidal zone. While *M. novaezelandiae* was present only in the northern sites during this study, this pattern may reflect their behaviour rather than real distribution. A subsequent survey at high tide at Bellerive Bluff found them to be abundant within the submerged intertidal zone.

While not identified to species, a tube forming polychaete created a dense matting on the substrate at sites between Geilston Bay and Bellerive Bluff, with this matting being most abundant within the 1-4.9 m depth band on reef (Appendix 5).

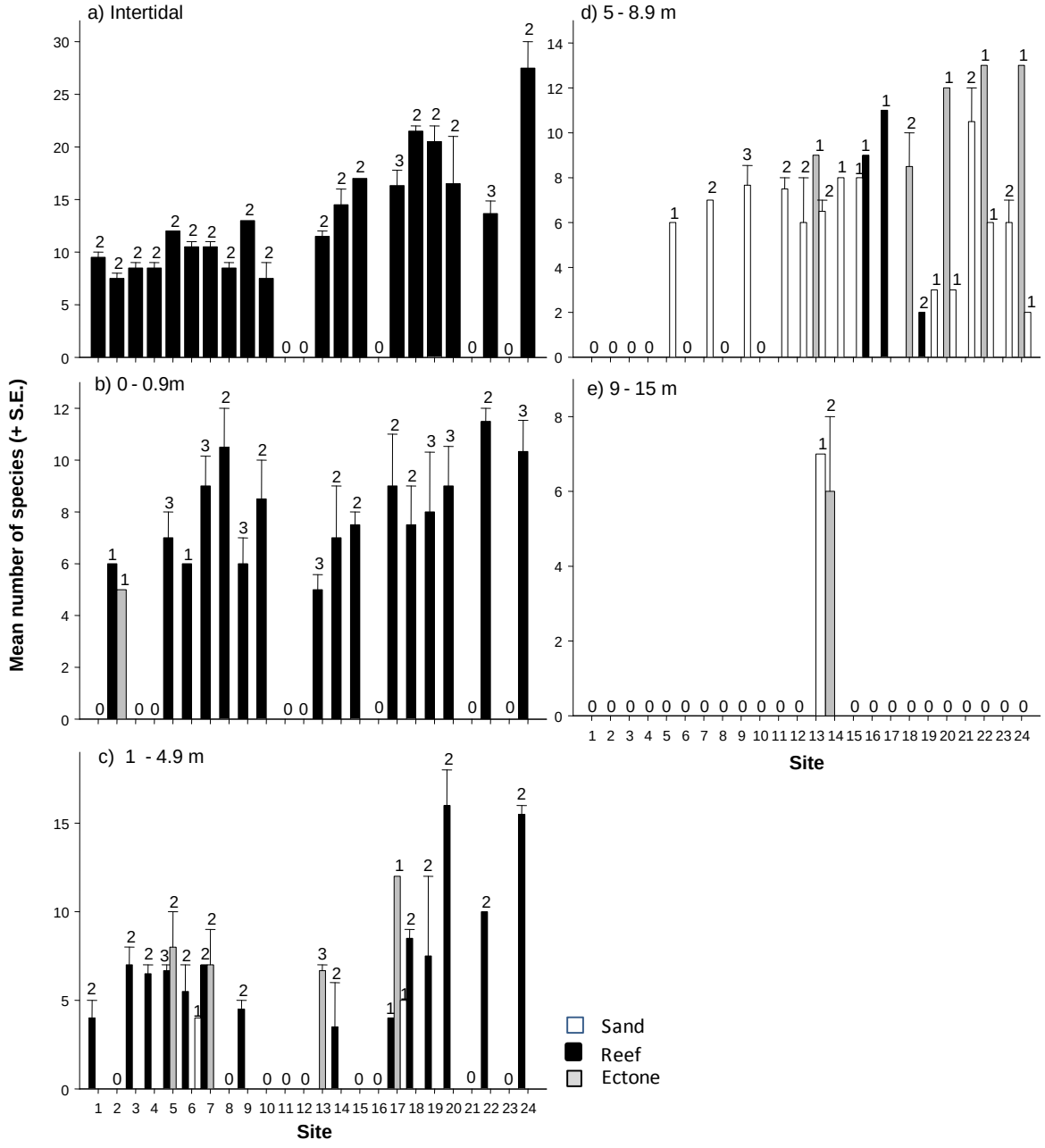

Figure 24. Mean diversity of invertebrate species in the Derwent on reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Numbers of searches undertaken at each site are above each bar.

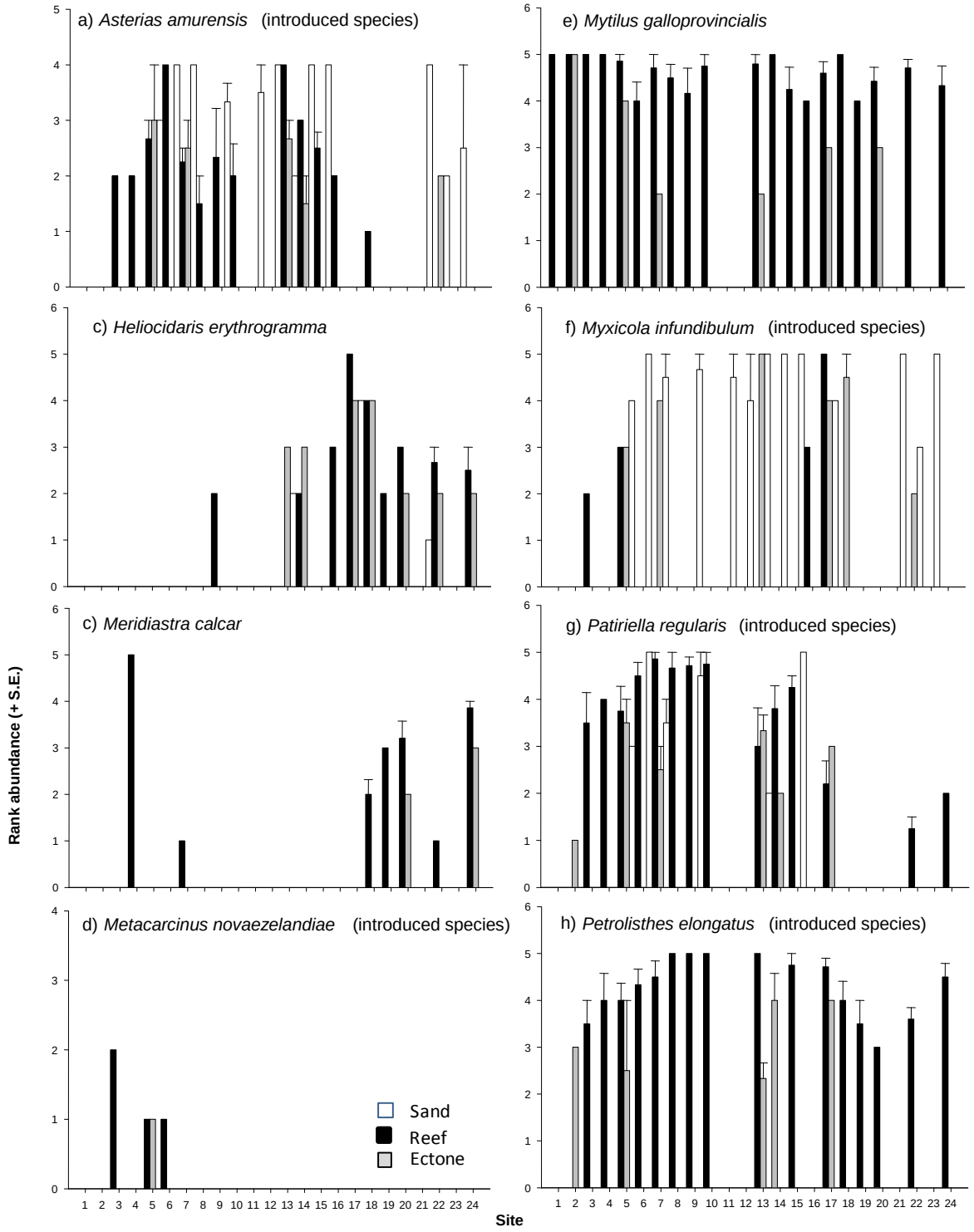

Figure 25. Mean rank abundance of the most abundant invertebrate species in the Derwent on reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Number of searches undertaken at each site and habitat are in table 1.

Algae

Over fifty nine taxa of algae and plants were sampled during the Derwent timed surveys. As discussed in the methods, algal surveys were generally restricted to the brown and green algae due to the available search time limitations imposed by a typically diverse red algal assemblage at marine sites and taxonomic difficulty in species identification for some divers. Several species of red algae were recorded, however, as these were of particular note (e.g. introduced species). Recorded algae comprised 31 species of brown algae, 16 species of green algae, 8 special interest species of red algae and 4 plants (Appendix 6).

As with standard surveys, with the exception of subtidal habitats of 9 – 15 m depths (where only 2 sites were sampled), the mean diversity of algae species generally increased from northern to southern sites within the estuary (Fig. 26). The mean number of algal species varied from one to two species at several northern sites to a maximum of 12 - 17 found at several southern sites, such as sites 19 (Crayfish Point) and 24 (Blackmans Bay Blowhole; Figs. 3, 26).

Generally, algal distribution was restricted to the shallow depth categories at the upper sites searched (Appendix 6), with sites upstream of Bellerive Bluff devoid of most species of foliose algae, particularly brown algae. The notable exception to this were *Ulva* (f. *Ulva*) species, which were present at most locations and depths, except at Cadbury Point, where it was replaced by *Ulva* (f. *Enteromorpha)* sp. *Enteromorpha* was abundant in shallow depths (0-1 m) at most locations in the mid-upper sites surveyed (Appendix 6). As with standard surveys, the most abundant brown foliose algae were *Ecklonia radiata*, and *Lessonia corrugata* (Figs. 27 d-e) with other brown algae, such as *Cystophora moniliformis* and *Dictyopteris muelleri*, increasing in abundance southwards from Bellerive Bluff (Figs. 2, 27b-e, Appendix 6). The Rosny Point to Bellerive Bluff area marked a clear demarcation between algal assemblages, with the first significant canopy forming species *E. radiata* appearing at Bellerive Bluff and extending to depths in excess of 5 m at that site (Fig. 27d, Appendix 6). The large surface canopy forming algae *Macrocystis pyrifera* was absent at all sites north of Blackmans Bay Blowhole, and also absent along the eastern shore, including White Rock. The introduced brown algae *Undaria pinnatifida* was recorded in moderate abundance from Tranmere Point and at all sites southward (Fig. 28c, Appendix 6), and formed a conspicuous component of the flora despite the survey period being later than its seasonal peak. Another introduced algae *Grateloupia turuturu*, a red algal species, was also recorded in moderate abundances in the 0-1 m depth band at some locations (Fig. 28b). The current peak in abundance was at Alum cliffs, although plants were distributed along both eastern and western shores of the estuary.

A distinctive foliose red alga *Aeodes nitidissima* was common to abundant in the mid-estuarine sites surveyed (Collegiate rowing club to Tranmere Point), forming a significant component of the flora at Rosny Point (Fig. 28a). While generally restricted to the 0-4.9 m depth band, it was also found at depths below 5 m at Bellerive Bluff (Appendix 6). While red algae were generally not surveyed, we noted the distribution of several *Gracillaria* species as these were often distinctive features of the flora at some locations. *Gracillaria ramulosa* was particularly common in the 0-0.9 m depth band at Dowsings Point, and notable as it was the only foliose algae present at that site other than *Enteromorpha* spp.

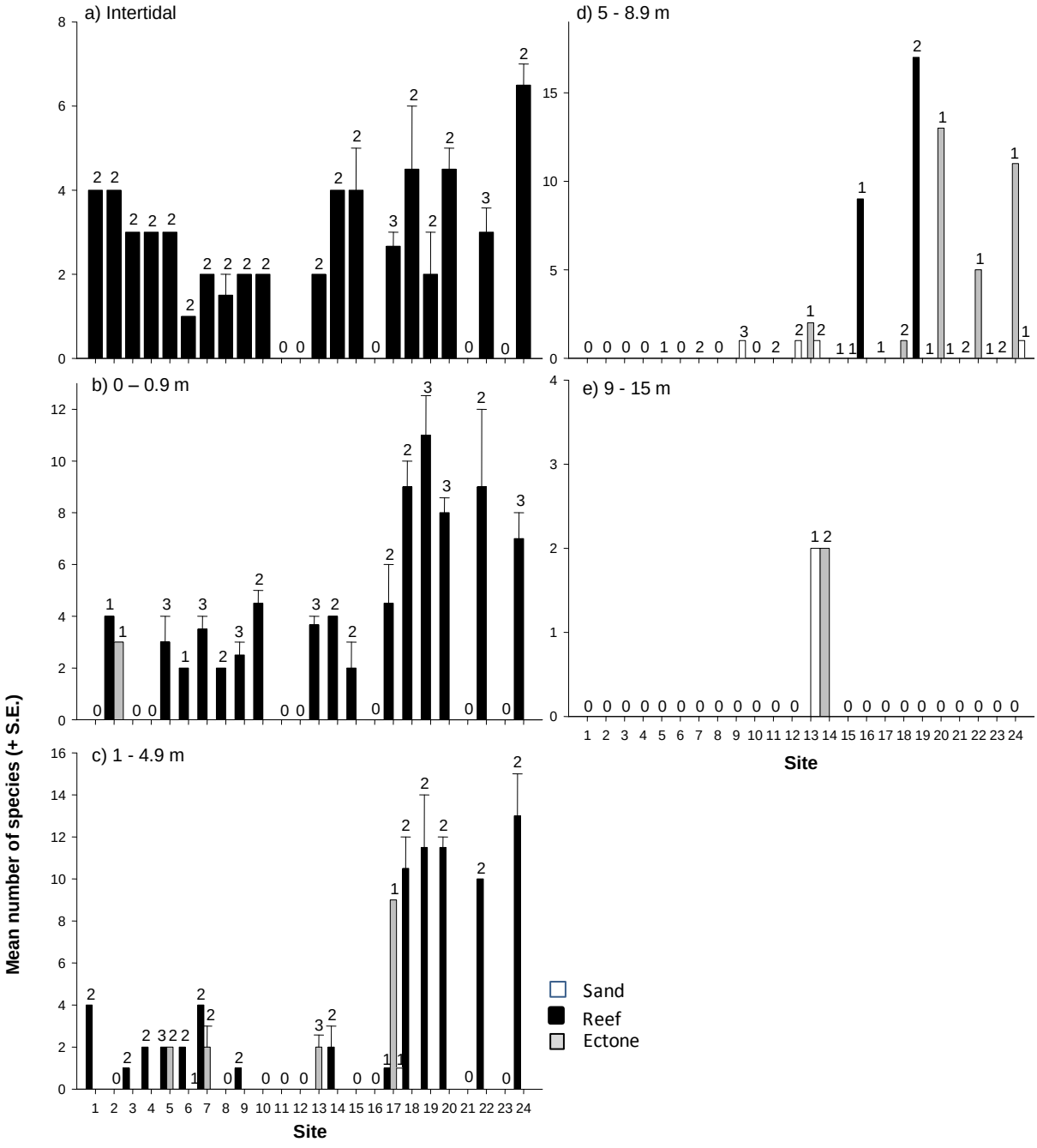

Figure 26. Mean diversity of foliose brown and green algal species in the Derwent on reef (black), ecotone (reef-sand; grey) and sand (white) habitats at different depths. Numbers of searches undertaken at each site are above each bar.

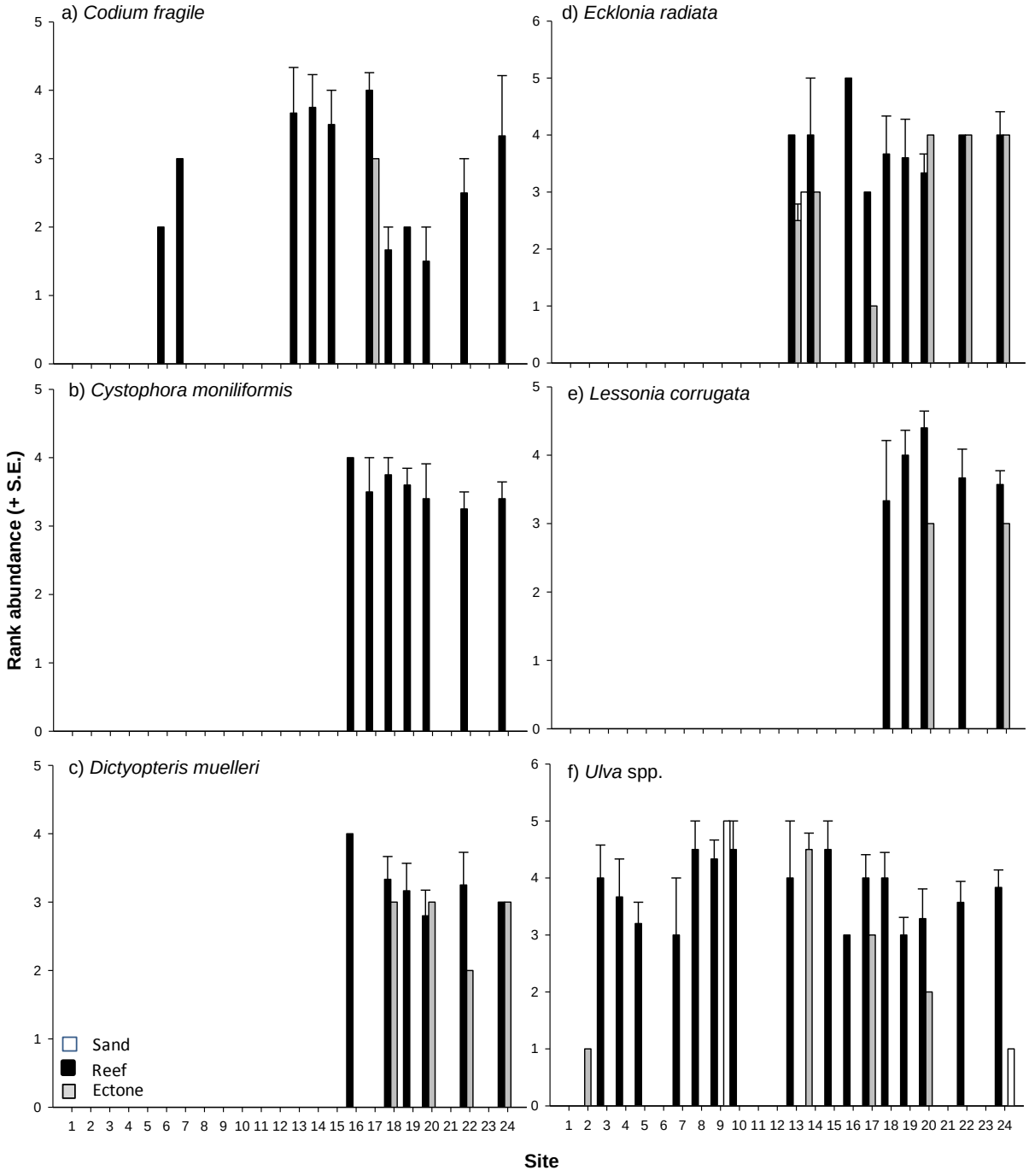

Figure 27. Mean rank abundance of the most abundant brown (b-e) and green (a, f) foliose algal species on the Derwent in reef (black), sand (white) and ecotone (reef-sand; grey) habitats at different depths. Number of searches undertaken at each site and habitat are in table 1.

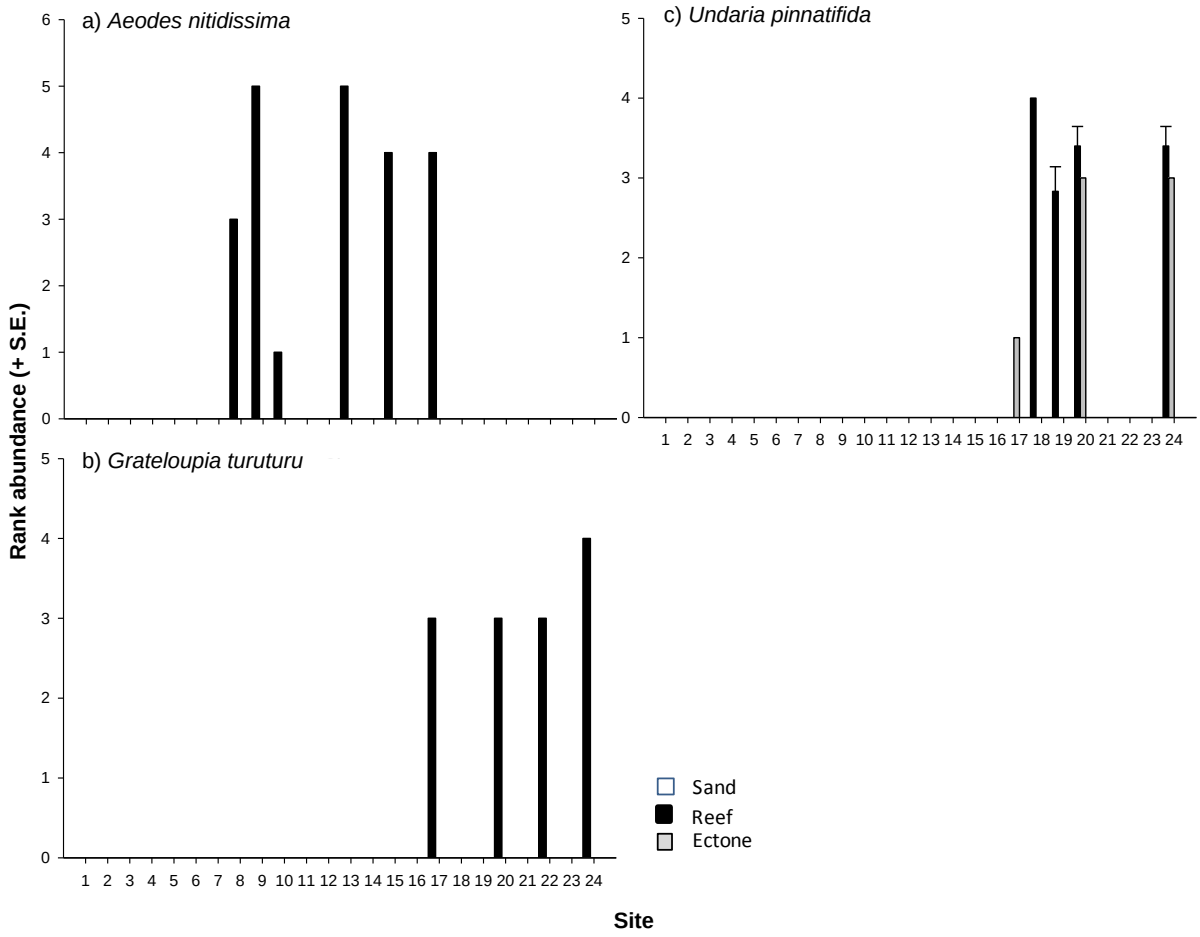

Figure 28. Mean rank abundance of introduced and likely-introduced red (a-b) and brown (c) algal species in the Derwent on reef (black) and ecotone (reef-sand; grey) habitats at different depths. Number of searches undertaken at each site and habitat are in table 1.

4. Discussion

This study was initiated with three main aims with respect to describing patterns of biodiversity within the Derwent estuary; (1) to examine the distribution of rare reef associated species, with a particular focus on determining the status of *M. littoralis*; (2) to quantitatively describe the distribution of reef associated biodiversity as a baseline and record for conservation management and planning, and; (3) to quantitatively describe the distribution of introduced species to better understand the threats that they pose to native biodiversity. Each of these focus areas is discussed in detail below.

Rare species

Marginaster littoralis

A significant focus of this study was on the distribution of *M. littoralis,* yet despite extensive searching of both intertidal and subtidal habitats within the described range of the species, no specimens were found. Intertidal searches were comprehensive within the type location and other museum collection locations recorded for the species. The locations and habitat from which it was originally described (Dartnall, 1970) is now extensively dominated by the seastar *P. regularis* and the crab *P. elongatus*, two introduced species that could readily prey upon or otherwise out-compete *M. littoralis*, even if a small population of this species was still present.

While *M. littoralis* was originally described from only the intertidal zone, it is highly unlikely that any persisting population of this species is restricted to this habitat within its described range. The mid-section of the estuary from which it is recorded is subject to freshwater conditions in surface waters during winter flood events (Barrett, unpublished data), and no freshwater tolerant species of seastar is known. If this species is valid, there must be, or have been, either a subtidal source population in the vicinity at depths below the freshwater layer, or an intertidal source population somewhere in the estuary or nearby, away from the region of seasonal low salinity. Our surveys detected no such populations, either on reef systems or on the adjacent sediment substrates. Certainly if they were present in the mid-section of the estuary, our results would suggest that the population may readily be out-competed by the super-abundance of the very similar species *P. regularis*, on both reef and sediment habitats in this area.

Our observations over the October-March period during which the core intertidal area of occupancy was repeatedly and thoroughly searched, indicated that this was a particularly harsh environment. This was due to not only the incidents of low salinity inundation during floods, but also extensive exposure to heat and drying during summer spring low tides. While that area of intertidal pavement was covered with high densities of *P. regularis* in October, they were virtually absent by January-February due to the combination of extended low tides and hot weather. Presumably resident seastars were either killed or moved subtidally. Very few rockpool refuges exist in this area and all were searched thoroughly, as were potential refuges under rocks.

One notable feature evident from the survey was the extreme morphological plasticity of *P. regularis*, a species that is very difficult to distinguish from *M. littoralis*. Distinguishing features that separate the species include colour, large marginal spines in the inter-radial area, a dense cluster of gills on the arm tips and an off-white band around the margins (Dartnall, 1970). In several locations, the colour morphs of *P. regularis* were similar to that described for *M. littoralis*, and some animals had white to off-white marginal bands (although these were restricted to the inter-radial margins). These were most notable in the vicinity of Cornelian Bay, the type location for *M. littoralis*. Given that it is not inconceivable that the described specimens of *M. littoralis* are one extreme ecotype of *P. regularis*, the next step in determining the conservation status of this species would be a thorough re-examination of the type specimens, and comparison with the ecotypic variability of *P. regularis* displayed at Cornelian Bay, to exclude the possibility of mis-identification of the species. A further potential option is to use molecular genetics to undertake this comparison. While this has not been possible to date due to the formalin fixed nature of the type series of specimens, new techniques are currently under development to overcome this limitation, and are worth pursuing as soon as they are sufficiently reliable and cost effective.

Other rare species

One aspect of this study focussed on developing appropriate survey techniques for describing the range of rare species on rocky reef systems. While *M. littoralis* was the only such reef-habitat species described from the Derwent Estuary, two other seastars, *Parvulistra vivipara* and *Smilasterias tasmaniae*, are known from localised populations in nearby locations and could readily have been present. While our survey methods were appropriate for detecting these species (often found under boulders around the low-tide mark), no individuals were detected, suggesting that if these species were present in the estuary their distribution would have to be restricted to smaller scale patches than the gaps between survey locations. Clearly though, if these species were truly rare, as well as range restricted, a significant proportion of habitat would need to be searched to detect sufficient individuals to discover patterns of distribution.

While the main focus of this study was on reef fauna, surveys at most sites included several replicated searches on adjacent sediments and/or the reef/sediment ecotone, and these included searches within the known range and depth preference of the spotted handfish. As only one individual was found (Appendix 4), this suggests that significantly greater search effort and number of sites would be required if the aim was to effectively describe the distribution of such rare and range-restricted species.

Quantitative description of species distributions

To our knowledge, this study provides the first quantitative baseline survey of the biota associated with rocky reefs within the Derwent estuary, allowing overall patterns of spatial distribution to be described. Previous studies, however, have described the distribution of individual taxa (e.g. *Asterias*, by Ling, 2000) and focussed on seastars such as *M. littoralis* (Materia, 1994a). Our dataset will provide an invaluable baseline from which to measure future changes within this system, and is complimented with data from two inter-related studies that further examine patterns within the estuary. The first of these is a Reef Life Survey project, utilising a volunteer network to collect reef associated biodiversity data from impacted estuaries associated with cities (Hobart, Melbourne and Sydney), and the second is a PhD project that further examines the impacts of these cities on reef biota. Both of these projects are expected to provide additional insights into the patterns observed here when their

findings are published.

Overall, many of the patterns we observed are as expected for an estuarine system (Remane, 1934; Edgar *et al.*, 1999), most notably a relatively depauperate flora and fauna at the riverine extreme, grading to a much greater diversity at the fully marine extreme. This gradient is presumably in response to a range of limiting physical factors such as freshwater influences, nutrient levels, sediment loading, overall water quality (limiting light availability) and water movement via exposure to waves and currents. Many of these are strongly correlated along this gradient so are difficult to impossible to distinguish from each other.

The biological gradient is typified by the algal/floral component that ranges from a seagrass/filamentous algae mix on shallow silt covered reef outcrops at the upper site (Cadbury Point), to a complex foliose algal assemblage at Pearsons Point (Tinderbox), where *Macrocystis pyrifera* (Giant kelp) forests are found, large canopy forming algae such as *E. radiata* form a significant proportion of the total cover, and reef surfaces are covered in encrusting sponges and coralline algae, with little silt. While such a gradient is to be expected, the large step in algal assemblages between Bellerive Bluff and Rosny Point is somewhat anomalous, given that *E. radiata* is moderately common at Bellerive Bluff (where it extends to depths of greater than 5 m), yet it is completely absent at Rosny Point and further upstream, even in the shallowest depths. This may be related to a wave exposure gradient; however, similar gradients in other estuarine systems in Tasmania including Bathurst Channel (Barrett and Edgar, 2004) and the D'Entrecasteaux Channel (Barrett and Edgar, unpublished data) suggest that *Ecklonia* would normally be expected to gradually decrease its lower depth limit with progression upstream, rather than to suddenly truncate its distribution.

One potential clue to the cause of this pattern may be the presence of extensive reef surface coverage of tube-worm matting (probably a spionid polychaete in the genus *Polydora*) at Rosny Point, Battery Point, and sites upstream towards Geilston Bay. This matting comprises almost 100% cover at most sites and reef depths in this region and it effectively traps silty sediments to make a thick rhizomatous carpet of approximately 2-3 mm thick. Such matting appears to be relatively common in estuarine systems (Thomsen and McGlathery, 2005). Certainly the matting would severely restrict the capacity for algal gametophytes to settle and develop, and also for large sporophyte algae like *Ecklonia* to become established. When coupled with high sediment loading and low light availability in turbid water, this matting may explain why algal assemblages have such a truncated pattern. It may also explain why algal assemblages, historically recorded from Rosny Point (Sanderson, 2000) have failed to re-establish, despite recent improvements to the water quality of the Derwent estuary (Whitehead *et al*., 2010). The polychaete mat may represent an alternate stable state for this habitat that may not be readily reversed. Clearly any future efforts to re-establish algal assemblages at Rosny Point and similar locations (such as the Seacare *Macrocystis* re-establishment program), need to establish what combination of physical factors are currently restricting algal establishment, and take into account the possibility that the tube-worm matting may play a significant role in this.

Introduced species

Introduced species constituted a significant component of the macro-invertebrate biomass within the Derwent Estuary, particularly within the mid-section extending from Bedlam Walls to Battery Point and Bellerive Bluff, where species such as *Patiriella regularis* and *Asterias amurensis* constituted more than 50% of the individuals counted on the quantitative

transect counts. On the timed-swim surveys, where a broader range of depths were examined, including the intertidal zone, other introduced species were also found to be particularly abundant, including the fanworm *Myxicola infundibulum* on soft sediments and the New Zealand Porcelain Crab *Petrolistes elongatus* in the mid to low intertidal zone. This latter species was super-abundant in the mid section of the estuary from Bedlam Walls to The Grange, and at locations such as Battery Point more than 100 individuals could be counted under a single rock. At such high densities, this species must clearly be having a significant impact on co-occurring native species including crabs, and our study at least forms a baseline from which further impacts on the native biota by such invasive species can be measured. Clearly, while little may be done at this stage to control the impacts of this species and other super-abundant species such as *P. regularis*, further research is needed to better understand their likely impacts on intertidal and estuarine reef biodiversity. If *Marginaster littoralis* is a valid species, its apparent loss/decline is most likely attributable to competition/predation by these dominant introduced pests. Outside the Derwent Estuary, several of our rarer species share similar sheltered habitats (particularly the seastars *Parvulastra vivipara* and *Smilasterias tasmaniae*), and species such as these may also be under a similar and significant threat from introduced species over the medium to long term.

Introduced species recorded covered a broad range of genera and included two fishes (*Grahamina gymnota* and *Forsterygion varium*), and the macroalgae *Undaria pinnatifida*, *Grateolupia turutura* and *Aodes nitidissima*. For several of these species, the current densities may be significant under-estimates of cover as, for example, the brown alga *U. pinnatifida* is an annual species, which peaks in biomass in late spring and is usually absent by late January. Moreover, the crab *Metacarcinus novaezelandiae* is particularly cryptic at low tide when the surveys were usually undertaken. A high tide examination at Bellerive Bluff in mid July indicated this species to be particularly abundant in the submerged intertidal zone, yet it was not recorded at all from this site in mid-January.

Several of the introduced species recorded were relative new to the estuary, and this study provided the first quantitative record of their occurrence. *Carcinus maenus* (green shore crab) has extended its range down the east coast of Tasmania over the past decade (Hobday *et al.*, 2008) and is now firmly established at sites such as Howrah Bluff within the intertidal zone. The red algae *Grateolupia turuturu* was first recorded in Tasmania 4 years ago (Saunders and Withall, 2006) and has now become widely established along the eastern Tasmanian coastline and in the Tamar estuary (Barrett, unpublished data). This latter species is likely to become a significant component of the intertidal to immediate subtidal flora of the estuary in coming years.

- Identification of threats and recommendations for improving habitat condition at key locations (where appropriate).

- Recommendations for future analysis and monitoring, including identification of areas for future dive surveys to provide information about other major representative areas (if not included in current or RLS work) and anomalous reef habitat areas that may provide habitat for less common species in the estuary.

5. Acknowledgments

We would like to acknowledge Amelia Fowles, Nicole Hill, and Dane Jones for assistance with fieldwork and Justin Hulls for preparing the maps. We would also like to acknowledge Jason Whitehead from the Derwent Estuary Program for organising and undertaking a series of low-tide intertidal searches for *M. littoralis* over the summer 2009/10 period and for facilitating this body of work through a granting process. This study was facilitated by a Caring for our Country program to the Derwent Estuary Program, an ARC-Linkage grant to Graham Edgar, and in-kind logistical support provided by the TAFI marine labs, courtesy of Prof. Colin Buxton.

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7. Appendix

Appendix 1. Total fish abundances recorded during standard surveys in February-April 2010, * = introduced species.

	Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27	**Total**
	Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4	
Species	**Common name/Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5	
Acanthaluteres spilomelanurus	Bridled leatherjacket	5	0	0	0	0	0	0	0	0	0	2	0	0	0	18	0	0	0	0	25
Acanthaluteres vittiger	Toothbrush leatherjacket	0	0	0	0	0	0	0	9	26	0	0	0	2	3	138	0	2	1	9	190
Aplodactylus arctidens	Marblefish	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	3	1	0	3	9
Aracana aurita	Shaws cowfish	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	3	1	3	1	12
Arenigobius bifrenatus	Bridled goby	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Arripis spp.	Australian salmon	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15
Blennid spp.	Blenny	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Cephaloscyllium laticeps	Draughtboard shark	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	5	0	1	10
Cheilodactylus nigripes	Magpie perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Cheilodactylus spectabilis	Banded morwong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6
Cristiceps australis	Crested weedfish	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6
Dinolestes lewini	Long-fin pike	0	0	0	0	0	0	0	0	0	0	0	0	502	0	61	171	0	7	1	742
Diodon nicthemerus	Globe fish	0	0	0	0	0	0	0	0	0	0	3	3	0	1	1	1	1	0	0	10
Dipturus whitleyi	Whitley's skate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Dotalabrus aurantiacus	Castelnaus wrasse	0	0	0	0	0	0	0	0	0	0	0	2	12	1	1	0	2	8	12	38
Eubalichthys gunnii	Gunn's leatherjacket	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Favonigobius lateralis	Long-finned goby	40	29	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82
Forsterygion varium	Many-rayed threefin *	0	18	12	55	0	10	12	52	18	21	172	0	0	0	0	2	0	0	0	372
Girella zebra	Zebra fish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Gobiid spp.	Unidentified goby	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Grahamina gymnota	Estuarine threefin *	0	35	0	2	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0	43
Hippocampus bleekeri	Pot-belly seahorse	5	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
Hippocampus spp.	Seahorse	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Latridopsis forsteri	Bastard trumpeter	0	0	0	0	0	0	0	0	1	0	0	386	0	13	130	232	5	3	114	884
Meuschenia australis	Brown-striped leatherjacket	0	0	0	0	0	0	0	0	0	0	0	2	0	6	1	0	2	0	2	13
Meuschenia freycineti	Six-spine leatherjacket	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	3
Myliobatis australis	Eagle ray	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Neoodax balteatus	Little rock whiting	0	0	1	0	0	2	0	2	10	3	17	4	11	0	24	2	1	3	2	82
Neosebastes scorpaenoides	Common gurnard perch	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Nesogobius hinsbyi	Hinsbys goby	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Notolabrus fucicola	Purple wrasse	0	0	0	0	0	0	0	0	0	0	2	11	1	7	13	2	4	8	19	67
Notolabrus tetricus	Blue-throat wrasse	0	0	1	0	0	0	0	3	6	0	23	43	126	109	40	77	107	76	57	668

Appendix 1 cont. Total fish abundances recorded during standard surveys in February-April 2010, * = introduced species.

	Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27	**Total**
	Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4	
Species	**Common name/Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5	
Olisthops cyanomelas	Herring cale	0	0	0	0	0	0	0	0	0	0	0	0	1	15	0	0	0	0	0	16
Parablennius tasmanianus	Tasmanian blenny	0	6	8	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	19
Pempheris multiradiata	Common bullseye	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	76	0	35	1	121
Pentaceropsis recurvirostris	Long-snouted boarfish	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	4
Phyllopteryx taeniolatus	Weedy seadragon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	5
Pictilabrus laticlavius	Senator wrasse	0	0	0	0	0	0	0	0	0	0	0	5	39	18	0	7	10	28	8	115
Platycephalid spp.	Flathead	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pseudocaranx georgianus	Silver trevally	0	0	0	0	0	0	0	0	0	0	0	85	0	0	0	20	0	0	0	105
Pseudolabrus psittaculus	Rosy wrasse	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Pseudophycis bachus	Red cod	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	4
Pseudophycis barbata	Bearded cod	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	4
Siphonognathus beddomei	Pencil weed whiting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Trachinops caudimaculatus	Hulafish	0	2638	3345	1490	106	145	228	107	98	233	1720	73	602	700	35	62	25	10	798	12415
Trachurus declivis	Jack mackerel	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	20	0	0	0	40
Unidentified pipefish	Unidentified pipefish	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Urolophus cruciatus	Banded stingaree	0	0	0	0	1	0	2	2	0	1	0	0	0	0	0	0	0	0	0	6
Vincentia conspersa	Southern cardinalfish	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Species richness (total species per site)		**4**	**6**	**7**	**5**	**4**	**6**	**4**	**7**	**7**	**8**	**12**	**15**	**13**	**17**	**13**	**17**	**14**	**13**	**18**	
Total species richness										**49**											

Appendix 2. Invertebrate and cryptic fish abundances recorded during standard surveys in February-April 2010, * = introduced species.

		Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27	**Total**
		Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4	
Species		**Common name/Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5	
Cryptic fish	Blennid spp.	Blenny	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
	Bovichtus angustifrons	Dragonet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Cephaloscyllium laticeps	Draughtboard shark	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	1
	Forsterygion varium	Many-rayed threefin *	0	0	0	46	0	27	8	34	14	12	71	1	0	0	0	8	0	0	0	221
	Gobiid spp.	Unidentified goby	0	11	5	0	0	0	4	22	5	0	0	0	0	0	0	0	0	0	0	47
	Grahamina gymnota	Estuarine threefin *	0	0	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	0	0	10
	Heteroclinus johnstoni	Johnstons weedfish	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3
	Hippocampus bleekeri	Pot-belly seahorse	1	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	5
	Nesogobius hinsbyi	Hinsbys goby	0	0	0	0	0	20	0	0	0	0	1	0	0	0	0	0	0	0	0	21
	Nesogobius maccullochi	Girdled goby	0	0	0	1	0	3	0	0	0	0	2	0	0	0	0	0	0	0	0	6
	Parablennius tasmanianus	Tasmanian blenny	0	0	0	0	0	2	3	1	0	1	0	0	0	0	0	0	0	0	0	7
	Pempheris multiradiata	Common bullseye	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	32	0	0	17	35
	Phyllopteryx taeniolatus	Weedy seadragon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	Scorpaena papillosa	Southern rock cod	0	0	0	0	0	0	1	3	2	0	1	2	2	6	2	16	4	0	2	39
	Trinorfolkia clarkei	Common threefin	0	0	0	0	0	2	5	6	0	0	0	2	4	2	1	1	4	0	0	27
Crustaceans	*Carcinus maenas*	Green crab *	0	0	0	3	0	0	0	0	0	3	8	0	0	0	0	0	0	0	0	14
	Cyclograpsus granulosus	Shore crab	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Halicarcinus ovatus	Three-pronged flat spider crab	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Jasus edwardsii	Southern rock lobster	0	0	0	0	0	0	0	0	0	0	0	0	20	1	0	3	6	8	28	66
	Metacarcinus novaezelandiae	Piecrust crab *	0	3	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8
	Nectocarcinus tuberculosus	Velvet crab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Pagurid spp.	Hermit crab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Petrolisthes elongatus	New Zealand porcelain crab *	0	0	13	0	1	17	0	0	1	0	0	0	0	0	0	0	0	0	0	32
	Palaemon serenus	Banded shrimp	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
	Plagusia chabrus	Red bait crab	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	10	1	10	4	28
	Unidentified hermit crab	Hermit crab	0	0	0	0	0	0	0	0	3	0	0	1	0	1	3	1	2	0	0	11

Appendix 2. cont. Invertebrate and cryptic fish abundances recorded during standard surveys in February-April 2010, * = introduced species.

		Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27	**Total**
		Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4	
Species		**Common name/Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5	
Echinoderms	*Amblypneustes ovum*	Short-spined urchin	0	0	0	0	0	0	0	0	0	0	0	48	0	0	43	0	0	0	0	91
	Asterias amurensis	Northern Pacific seastar *	0	16	10	9	2	5	9	5	2	26	0	0	0	0	0	0	0	0	0	84
	Australostichopus mollis	Sea cucumber	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	2	0	0	6
	Comanthus tasmaniae	Tasmanian feather star	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	7	5	0	9
	Comanthus trichoptera	Orange feather star	0	0	0	0	0	0	0	0	0	0	0	0	25	8	0	24	27	90	450	624
	Coscinasterias muricata	Eleven-arm star	0	0	0	0	0	0	0	1	0	0	3	1	0	0	1	5	2	0	0	13
	Goniocidaris tubaria	Pencil urchin	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0	0	7
	Heliocidaris erythrogramma	Purple urchin	0	0	0	0	0	0	0	105	20	42	163	100	11	49	17	23	191	153	95	969
	Meridiastra calcar	Eight-armed seastar	0	0	0	0	0	0	0	0	0	1	0	1	0	253	0	220	14	0	0	489
	Patiriella regularis	Regular seastar *	0	232	80	19	173	244	507	124	97	372	3	0	0	0	0	2	0	0	0	1853
	Petricia vernicina	Velvet star	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	5	8
	Tosia australis	Southern biscuit star	0	0	0	0	0	0	0	0	0	0	0	8	0	0	1	0	1	1	0	11
	Tosia magnifica	Magnificent biscuit star	0	0	0	0	0	0	0	1	1	0	3	0	0	0	0	1	2	0	0	8
	Uniophora granifera	Granular seastar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3
Molluscs	*Agnewia tritoniformis*	Murex shell	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0	6
	Argobuccinum pustulosum	Triton shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	3
	Austrocochlea spp.	Top shell	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	6
	Cabestana spengleri	Triton shell	0	0	0	0	0	0	0	0	1	0	2	0	0	36	2	17	28	0	0	86
	Cominella lineolata	Lined whelk	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	2	0	0	0	9
	Dicathais orbita	Dog whelk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7	2	1	12
	Haliotis rubra	Blacklip abalone	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	1	7	17	5	34
	Pleuroploca australasia	Tulip shell	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2
	Scutus antipodes	Elephant snail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	3
	Turbo undulatus	Turban shell	0	0	0	0	0	0	0	0	0	0	0	0	1	40	7	7	17	0	0	72
Species richness (total species per site)			**3**	**6**	**5**	**7**	**4**	**8**	**8**	**14**	**15**	**8**	**12**	**11**	**8**	**16**	**17**	**23**	**20**	**10**	**10**	
Total species richness												**50**										

Appendix 3. Average algal percentage covers per site, recorded during standard surveys in February-April 2010, * = introduced species.

	Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27
	Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4
Species	**Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5
Brown algae	*Acrocarpia paniculata*	0	0	0	0	0	0	0	0	0	0	0	25.4	22.7	2.8	4.1	2.3	0.5	6.9	7.5
	Carpoglossum confluens	0	0	0	0	0	0	0	0	0	0	0	0	11.9	7.3	48.5	13.4	21.0	7.7	20.2
	Caulocystis cephalornithos	0	0	0	0	0	0	0	0	0	0	1.5	2.0	0	0	0	0	0	0	0
	Caulocystis uvifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0
	Cladostephus spongiosus	0	0	0	0	0	0	0	0	0	0	0.5	2.8	4.5	0.9	0	2.7	0	0	0
	Cystophora moniliformis	0	0	0	0	0	0	0	0	0	0	0	0.6	2.2	0	0.6	3.5	0	0	0
	Dictyopteris muelleri	0	0	0	0	0	0	0	0	0	0	0	2.0	3.6	11.3	0	6.4	0	0	0
	Dictyota dichotoma	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	4.3	0	0	0	0
	Ecklonia radiata	0	0	0	0	0	0	0	9.2	5.4	0	0	28.2	18.8	2.0	32.0	24.6	40.6	23.5	73.6
	Halopteris paniculata	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
	Lessonia corrugata	0	0	0	0	0	0	0	0	0	0	0	0	17.3	43.7	0	21.0	0.9	14.1	0.4
	Macrocystis pyrifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.0	18.2	0.8	1.4
	Perithalia caudata	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0
	Sargassum fallax	0	0	0	0	0	0	0	0	10.2	0	0.2	10.0	3.7	6.4	0.9	1.6	5.3	1.9	1.2
	Sargassum verruculosum	0	0	0	0	0	0	0	0	0	0	0	0	1.6	3.2	0	0	0.5	0	0
	Sporochnus comosus	0	0	0	0	0	0	0	0	3.2	0	7.9	0	0	1.0	0	0	0	0.2	0
	Undaria pinnatifida *****	0	0	0	0	0	0	0	0	0	0	0	3.6	1.9	1.8	0	0	0	0	0
	Unidentified algae (brown turf)	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0
	Unidentified algae (filamentous brown)	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0
	Xiphophora gladiata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0
	Zonaria turneriana/angustata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0
Green algae	*Bryopsis* spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
	Caulerpa geminata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
	Caulerpa longifolia	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0
	Caulerpa simpliciuscula	0	0	0	0	0	0	0	0	0	0	0	0	5.6	0.8	0	0	0	1.0	0.2
	Caulerpa trifaria	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0.7	0	2.6	4.3
	Codium harveyi	0	0	0	0	0	0	0.6	1.6	0	7.4	1.3	0	0	0	0	0	0	0	0
	Ulva spp. (f. *Enteromprpha*)	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ulva spp.	0	0	0	0	0	0	0	0	1.6	0	0	3.2	0	1.8	0.5	0	0	0	0
	Unidentified algae (green turf)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0
Red algae	*Aeodes nitidissima* *****	0	0	0	0	0	10.6	1.2	2.8	0	0	0	0	0	0	0	0	0	0	0
	Areschougia spp.	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0	0
	Ballia callitricha	0	0	0	0	0	0	0	0	1.0	0	0	0	2.0	0.9	0	1.8	0.8	0	2.6
	Callophyllis rangiferina	0	0	0	0	0	0	0	0	0	0	0	0	7.7	3.1	2.4	5.3	1.9	6.7	0.8
	Ceramium spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	1.6	0

Appendix 3. cont. Average algal percentage covers per site, recorded during standard surveys in February-April 2010, * = introduced species.

	Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27
	Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4
Species	**Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5
Red algae	*Champia viridis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0.4
	Craspedocarpus ramentaceus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
	Delisea pulchra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0
	Echinothamnion hystrix	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0.8	0	0	0
	Euptilota articulata	0	0	0	0	0	0	0	0	0	0	0	0	5.3	0	0	0	3.1	0.4	0
	Gelidium pusillum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5	1.0	0	0
	Gigartina muelleriana	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0
	Gracilaria ramulosa	14.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Grateloupia turuturu *****	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
	Halymenia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0
	Hemineura frondosa	0	0	0	0	0	0	0	0	0	0	0	0	2.3	1.4	1.0	6.8	1.2	9.1	0
	Hypnea spp.	0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0
	Jeannerettia lobata	0	0	0	0	0	0	0	0	0	0	0	5.4	9.9	14.8	7.7	7.3	1.5	0.7	0
	Laurencia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0
	Lenormandia marginata	0	0	0	0	0	0	0	0	0	0	0	0	2.9	0.6	3.4	0	3.4	10.3	9.6
	Mastophoropsis canaliculata	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0
	Nemastoma feredayae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
	Peyssonnelia novaehollandiae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.5
	Peyssonnelia spp. (encrusting)	0	0	0	0	0	0	0	13.0	13.0	0	63.8	44.4	21.1	16.3	49.6	13.9	23.7	8.2	9.1
	Phacelocarpus alatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	1.6
	Phacelocarpus peperocarpos	0	0	0	0	0	0	0	0	0	0	0	0	4.6	0	0	0	5.1	15.6	0.9
	Plocamium angustum	0	0	0	0	0	0	0	0	0	0	0	1.8	25.8	4.8	0	3.6	2.5	5.2	2.6
	Plocamium cartilagineum	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
	Plocamium dilatatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	2.6	6.5
	Polyopes constrictus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	1.0	0	0
	Pterocladia capillacea	0	0	0	0	0	0	0	0	0	0	0	0.6	0.5	3.9	0	0	0	0	0
	Ptilonia australasica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.9
	Rhodymenia sonderi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	6.0
	Rhodymenia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	0	0
	Sonderopelta coriacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9
	Stenogramme interrupta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	2.4
	Thamnoclonium dichotomum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	Tsengia feredayae	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0.3	0	0	0
	Unidentified algae (crustose coralline)	0	0	0	0	0	0	0	0	0	0	0	0.6	11.3	12.7	10.1	6.7	26.9	6.3	13.8
	Unidentified algae (filamentous red)	24.6	1.6	17.6	2.4	0	0.6	8.6	0	0	6.4	0	0	0	0	0	0	0	0	0
	Unidentified algae (foliose red)	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0.6	0	1	3.6	1.7
	Unidentified algae (red turf)	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	14.1	15.7	0	0.7

Appendix 3. cont. Average algal percentage covers per site, recorded during standard surveys in February-April 2010, * = introduced species.

	Site	1	3	4	5	6	7	9	13	14	15	17	18	19	20	22	24	25	26	27
	Number of transects	2	2	2	2	2	2	2	2	2	2	4	2	4	4	4	4	4	4	4
Species	**Depth(m)**	1	4	4	3	2	2	4	4	5	2	3	4	4	5	4	5	5	5	5
Sessile invertebrates	*Corynactis australis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0
	Crassostrea gigas *	2.4	1.4	0.8	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0
	Culicia tenella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
	Erythropodium sp. (grey)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.0	0
	Galeolaria spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
	Herdmania grandis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
	Mytilus galloprovincialis	0.6	0	0	0	0	0	0	0	0	0	0	0	0	2.2	4.0	0	0	0	0
	Ostrea angasi	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	25.2	3.0	0	0	0
	Oulactis mucosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0
	Phlyctenanthus australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0
	Pyura australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
	Pyura gibbosa	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2	0	7.4	0	0	0
	Anemones	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	1.0	0.8	0	0
	Ascidians	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0
	Bryozoans (encrusting)	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0
	Bryozoans (soft)	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	1.1	5.0
	Hydroids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	Invertebrates (encrusting)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2	0	1.0	3.0
	Invertebrates (tube matting) with turf/sand/sediment matrix	0	85.8	84.2	83.6	92.6	66.0	71.8	58.2	69.8	72.6	0	0	0	0	0	0	0	0	0
	Sponges (encrusting)	0	0	0	0	0	0	0	0	0	0	0	0.6	49.0	32.2	12.4	48.8	22.4	50.2	41.5
	Sponges	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	3.6	5.6	2.8	9.6
Other	Bare rock (non - barrens)	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	1.8	0
	Cobble	34.6	88.2	10.0	6	51.0	39.8	21.8	0	0	2.0	10.8	0	0	0	0	0	23.0	0	0
	Gravel	31.0	11.2	0	0	0	34.0	26.0	0	0	0	9.0	0	37.4	0	0	21.6	0	8.2	0
	Heterozostera tasmanica	21.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sand	0	0	0	0	0	0	0	25.0	0	0	7.2	19.4	0	20.0	19.4	13.8	8.8	0	2.1
	Shell	0	0	0	0	0	0	0	0	0	23.8	0	0	0	0	3.6	0	0	0	0
	Silt on reef	32.0	0.6	11.6	0	8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Turf/sand/sediment matrix	0	0	0	0	0	0	0	0	0.0	0	0	0	0	33.4	0	0	0	1.0	0
	Unidentified algae (drift)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18.0	0	10.0	0	0
	Unidentified algae (turf)	37.8	0	0	0	0	0	0	0	4.4	0	6.9	33.0	19.2	25.4	12.8	13.6	9.0	0	1.0
Species richness (total species per site)		**7**	**3**	**3**	**2**	**1**	**4**	**4**	**9**	**11**	**4**	**10**	**20**	**31**	**37**	**22**	**41**	**31**	**37**	**35**
Total species richness											**95**									

Appendix 4. Rank abundances of fish recorded during timed surveys (sites 1–9) in February-March 2010. Depth. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	**1**				**2**				**3**				**4**				**5**												**6**								**7**												**8**				**9**							
	Depth category	**-1**		**1**		**-1**		**0**		**-1**		**1**		**-1**		**1**		**-1**		**0**			**1**					**2**		**-1**		**0**				**1**			**2**	**-1**		**0**			**1**		**2**			**-1**		**0**			**1**		**2**		
	Habitat	**R**		**R**		**R**		**R**	**E**	**R**		**R**		**R**		**R**		**R**		**R**			**R**			**E**		**S**		**R**		**R**			**R**		**E**		**S**	**R**		**R**			**R**		**S**			**R**		**R**			**R**		**S**		
Species	**Common name/ Survey**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**1**		**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**
Acanthaluteres spilomelanurus	Bridled leatherjacket			1																																																					
Afurcagobius tamarensis	Tamar goby							2												3			2									2									3																3		
Alabes dorsalis	Common shore eel																	1	1																			1								1					2								
Aracana aurita	Shaws cowfish																						1																																			
Arenigobius bifrenatus	Bridled goby			1																																																				
Arripis trutta	Australian salmon																																																							
Atherinid spp.	Unidentified hardyheads																																																						
Brachaluteres jacksonianus	Pygmy leatherjacket							1																																																	
Diodon nicthemerus	Globe fish											1				2								1																																			
Eocallionymus papilio	Painted stinkfish																																																						
Favonigobius lateralis	Long-finned goby			1								2				3	3						2																																			
Forsterygion varium	Many-rayed threefin *											3				2							2	1	2	2	1																															
Galaxiid spp.	Galaxid fish							5																																																
Gobiid spp.	Unidentified goby			1																																																			
Grahamina gymnota	Estuarine threefin *											2								2				1		1																															
Heteroclinus perspicillatus	Common weedfish																																																					
Hippocampus bleekeri	Pot-belly seahorse			2								1																																											
Meuschenia freycineti	Six-spine leatherjacket																							1																															
Monacanthid spp.	Unidentified leatherjacket																									1																													
Neoodax balteatus	Little rock whiting																										1																												
Nesogobius hinsbyi	Hinsbys goby																										2																												
Nesogobius maccullochi	Girdled goby							3													4																																				
Notolabrus tetricus	Blue-throat wrasse																																																					
Omegophora armilla	Ringed toadfish																									1																												
Parablennius tasmanianus	Tasmanian blenny											1	2			2							2	1		3																													
Parapriacanthus elongatus	Slender bullseye																																																					
Platycephalus bassensis	Sand flathead																																																				
Pseudaphritis urvillii	Congolli																																																				
Scorpaena papillosa	Southern rock cod																																																			
Trachinops caudimaculatus	Hulafish											5	4			5					3	4	4	4	4	3																													
Trinorfolkia clarkei	Common threefin							1																																													
Tripterygiid spp.	Unidentified threefin																																																			
Urolophus cruciatus	Banded stingaree																																																			
Vincentia conspersa	Southern cardinalfish											1												1																															
Species richness (total sps per depth & habitat)				1	4			3	2			2	7			1	6	1	1	2	2	3	3	8	4	7						1	6	7	1		1		3	4		3	4	3	8	3	2		1	6	3		1	2	5	5	1	8	4	3	5
Total species richnes (total sps per site)			5				5				7				6										16						10												14									8							18				

Appendix 4. cont. Rank abundances of fish recorded during timed surveys (sites 10–18) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	10			11		12		13									14								15				16		17							18									
	Depth category	-1	0		2		2		-1	0			1			2			3		-1	0		1		2	3		-1		0		2		2			0		1			2			
	Habitat	R	R		S		S		R	R			E			E	S		S		R	R		R		S	E		R		R					R			R			E			
Species	Common name/ Survey	1	1	2	1	2	1	2	1	1	2	3	1	2	3	1	1	2	1	2	1	2	1	2	3	1	2	1	2	1	2	1	2	3	1	2	1	1	1	2	1	2	1	2	1	2
Acanthaluteres spilomelanurus	Bridled leatherjacket																													3																
Acanthaluteres vittiger	Toothbrush leatherjacket																			2																										
Afurcagobius tamarensis	Tamar goby															3						1					3																		3	
Alabes dorsalis	Common shore eel			2																						1	1																		
Ammotretis rostratus	Righteye flounder																																				1								
Aplodactylus arctidens	Marblefish																																		1	2									
Aracana aurita	Shaws cowfish																							1						1							1	1								2
Arripis trutta	Australian salmon		3	3							2								1											3					1		4								
Atherinid spp.	Unidentified hardyheads									4																									4										
Blennid spp.	Blenny																							2																					
Brachaluteres jacksonianus	Pygmy leatherjacket																						1																						
Brachionichthys hirsutus	Spotted handfish															1																													
Cephaloscyllium laticeps	Draughtboard shark																													2															1	
Dinolestes lewini	Long-fin pike																													4																
Diodon nicthemerus	Globe fish													1						1	2			2						1					2						1	2	1			
Dipturus whitleyi	Whitley's skate											1																																	
Dotalabrus aurantiacus	Castelnaus wrasse																																										1	1		
Forsterygion varium	Many-rayed threefin *							1			2	3		3	4	2				3	2	4					3			3					3		3		3		3			2		
Girella zebra	Zebra fish																																		1										
Gobiid spp.	Unidentified goby													3	3		3																												
Grahamina gymnota	Estuarine threefin *		3	3						3	3	4							1	3				1						3			1		3	3		2	3	1					
Heteroclinus perspicillatus	Common weedfish		1									2																							2	1					1				
Hippocampus bleekeri	Pot-belly seahorse							1						2							1								1																
Latridopsis forsteri	Bastard trumpeter																			1																							4	2			
Lepidotrigla papilio	Spiny gurnard															1						1																							
Leptatherina presbyteroides	Hardyhead																		3																	3									
Meuschenia freycineti	Six-spine leatherjacket																																										1			
Neoodax balteatus	Little rock whiting												2	2	3		1	1			3	1			2					3	3							1			1	2		2	
Nesogobius hinsbyi	Hinsbys goby					3		3							2																							1						2	
Nesogobius maccullochi	Girdled goby											2																																	
Nesogobius spp.	Goby																			2																										
Notolabrus fucicola	Purple wrasse																				1									2					2	2						1			
Notolabrus tetricus	Blue-throat wrasse											3							2	2	3									3	4				2	3					2	3	3		

Appendix 4. cont. Rank abundances of fish recorded during timed surveys (sites 10–18) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand.

	Site	10				11		12		13								14									15				16		17								18								
	Depth category	-1		0		2		2		-1	0			1			2				3	-1	0		1		2	3			2		-1			0		1			2	-1	0		1		2
	Habitat	R		R		S		S		R	R			E			E	S			S	R	R		R		S	E			R		R			R		R			E	R	R		R		E
Species	Common name/ Survey	1	2	1	2	1	2	1	2	1	1	2	3	1	2	3	1	1	2	3	1	1	1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	1	1	1	1	2	1	2	1	2	1	2
Omegophora armilla	Ringed toadfish																								1					1																		1
Parablennius tasmanianus	Tasmanian blenny			3							2	3	3										3				1	3				1				3	2	1					2				
Pegasus lancifer	Sculptured seamoth																1																															
Pempheris multiradiata	Common bullseye																								2					2								2									
Phyllopteryx taeniolatus	Weedy seadragon																																						2								
Pictilabrus laticlavius	Senator wrasse																													1																	
Platycephalid spp.	Flathead													1			1																															
Platycephalus bassensis	Sand flathead					3	3	2	2							1	3								2					1									1	1	2					2	2
Pseudolabrus psittaculus	Rosy wrasse																				1																										
Pseudophycis bachus	Red cod						1										2													2									1						
Pseudophycis barbata	Bearded cod																								1																					
Scorpaena papillosa	Southern rock cod													1	2																															
Trachinops caudimaculatus	Hulafish											2	3	4	4		3				2				4	4		3	4			4	1					4					4	3			
Trachurus novaezelandiae	Yellow-tail scad													2																															
Trinorfolkia clarkei	Common threefin																								2												2									
Tripterygiid spp.	Unidentified threefin												2				2																													
Urolophus cruciatus	Banded stingaree						2		1				1	1			1													2									2	1				1	2	2
Urolophus paucimaculatus	Sparsely spotted stingaree																												2																	
Species richness (total sps per depth & habitat)				3	4	1	4	1	5		3	3	9	3	8	6	7	2	4	5		2	5	9	8	4	3	7	1	1	1	2	3	9	12		1	7	9	4	10	6	4		1	4	8	10	5	5
Total species richnes (total sps per site)			5				4		5					25										25							5			18						21							21			

Appendix 4. cont. Rank abundances of fish recorded during timed surveys (sites 19–24) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand.

	Site	19									20								21		22								23		24									
	Depth category	-1		0			1		2		-1		0			1		2	2		-1			0		1		2	2		-1		0			1		2	
	Habitat	R		R			R		R	S	R		R			R		E	S	S	R			R		R		E	S	S		R		R			R		E	S
Species	Common name/ Survey	1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	2	1	1	1	2	1	2	3	1	2	1	1
Acanthaluteres vittiger	Toothbrush leatherjacket							2							1										3		3		3											
Aplodactylus arctidens	Marblefish				2		1																													1	1		
Aracana aurita	Shaws cowfish									1			1			1	1													1			1			2			
Arripis trutta	Australian salmon																	4																					
Brachaluteres jacksonianus	Pygmy leatherjacket						1																				1												
Callorhinchus milii	Elephant fish																												1									
Cyttus australis	Silver dory																			1																			
Dasyatis brevicaudata	Smooth stingray																										1											
Dinolestes lewini	Long-fin pike						4		4				2				3									4		3					3			4			
Diodon nicthemerus	Globe fish												1													1										1			
Dotalabrus aurantiacus	Castelnaus wrasse						2	2	2				1			1	1									1		1											1
Forsterygion varium	Many-rayed threefin *						1									1		1																					
Heteroclinus johnstoni	Johnstons weedfish							1																															
Heteroclinus perspicillatus	Common weedfish																								1														
Latridopsis forsteri	Bastard trumpeter						3	1	2							1										1	2						2			3	2	1	
Lepidotrigla modesta	Rough cocky gurnard																												1									
Leptatherina presbyteroides	Hardyhead									4																													
Meuschenia australis	Brown-striped leatherjacket														1																		1						
Meuschenia freycineti	Six-spine leatherjacket																																1						
Neoodax balteatus	Little rock whiting					1	3	2	3																	2	2	2											2
Neosebastes scorpaenoides	Common gurnard perch							1												1									1										
Nesogobius hinsbyi	Hinsbys goby																				3						2											
Nesogobius maccullochi	Girdled goby																												3									
Notolabrus fucicola	Purple wrasse			2			2						3	1	2	2	2								2	2	2	4					3	2	1	1	2		
Notolabrus tetricus	Blue-throat wrasse			2	2	2	4	3	3	1			3			3	3	3								2	2	3	3					2		2	3	3	3
Omegophora armilla	Ringed toadfish						1																															
Parablennius tasmanianus	Tasmanian blenny												1		1											2												
Pempheris multiradiata	Common bullseye						3											2									3	2										
Phyllopteryx taeniolatus	Weedy seadragon																										1											2
Pictilabrus laticlavius	Senator wrasse						2	3	3							2		2																					
Platycephalus bassensis	Sand flathead									2										3	3								1	3	3							
Pseudophycis bachus	Red cod																				1															1			
Sarda australis	Australian bonito																																	2					
Scorpaena papillosa	Southern rock cod						2																																
Scorpis aequipinnis	Sea sweep				1																																		
Trachinops caudimaculatus	Hulafish				3		4		4	4			3			4	3									5		3											
Trinorfolkia clarkei	Common threefin							1																														1	
Urolophus cruciatus	Banded stingaree																				2						1											
Urolophus paucimaculatus	Sparsely spotted stingaree								1	2								1			1								2										1
Species richness (total sps per depth & habitat)				2	4	3	14	9	8	6			8	1	4	8	6	6		3	5				1	5	11	8	7	1	4	4	1	1	7	1	3	8	5	6
Total species richnes (total sps per site)							24									16				7						18				7						17			

Appendix 5. Rank abundances of invertebrates recorded during timed surveys (sites 1–9) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	1				2				3				4			
	Depth category	-1		1		-1		0		-1		1		-1		1	
	Habitat	R		R		R		R	E	R		R		R		R	
Species/ Replicate search		1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	2
Ascidians	*Ascidiella aspersa*																
	Eudistoma constrictum																
Barnacles	*Elminius* spp.																
	Unidentified barnacles	5	5			5	5			5	5			5	5		
Crustaceans	*Brachynotus spinosus*	2	2														
	Carcinus maenas *					2	3	2		2							
	Cyclograpsus granulosus	2	2			3	4	2		3	3	1		3	3		
	Ebalia intermedia																
	Halicarcinus ovatus	1															
	Halicarcinus rostratus							1									
	Helograpsus haswellianus	4	4				1										
	Metacarcinus novaezelandiae *												2				
	Palaemon dolospina				3								4				4
	Palaemon intermedius																
	Palaemon serenus			4				2	3							1	
	Paragrapsus gaimardii	4	4		2	4	4			4	4			4	4		
	Paragrapsus quadridentatus											1		2	2		
	Petrolisthes elongatus *								3	3	3	3	5	3	3	5	5
Echinoderms	*Amphiura constricta*																
	Amphiura elandiformis																
	Asterias amurensis *												2			2	2
	Heliocidaris erythrogramma																
	Meridiastra calcar															5	
	Patiriella regularis *								1	2	3	5	4	4	4		4
	Tosia magnifica																
	Uniophora granifera																
Flatworms	*Notoplana australis*															1	

	Site	5											6					
	Depth category	-1		0			1					2	-1		0	1		
	Habitat	R		R			R			E		S	R		R	R		S
Species/ Replicate search		1	2	1	2	3	1	2	3	1	2	1	1	2	1	1	2	1
Ascidians	*Ascidiella aspersa*										2	3						
	Eudistoma constrictum																	
Barnacles	*Elminius* spp.													3				
	Unidentified barnacles	5	5										5					
Crustaceans	*Brachynotus spinosus*																	
	Carcinus maenas *	2	2	2	3	2		1			1		4	2		1	1	
	Cyclograpsus granulosus	3	3										3	3				
	Ebalia intermedia											1						
	Halicarcinus ovatus	1	2											1			2	
	Halicarcinus rostratus											2						
	Helograpsus haswellianus		2															
	Metacarcinus novaezelandiae *						1		1	1						1		
	Palaemon dolospina																	
	Palaemon intermedius					4												
	Palaemon serenus			2	3			2							4		3	
	Paragrapsus gaimardii	4	4		2								4	3				
	Paragrapsus quadridentatus	2	2											2				
	Petrolisthes elongatus *	4	4			5	3	3	5	1	4		5		4		4	
Echinoderms	*Amphiura constricta*																	
	Amphiura elandiformis																	
	Asterias amurensis *					2		3	3	4	2	3				4		4
	Heliocidaris erythrogramma																	
	Meridiastra calcar																	
	Patiriella regularis *	5	5	4	4	5	2	1	4	3	4	3		4	5	5	4	5
	Tosia magnifica																	
	Uniophora granifera																	
Flatworms	*Notoplana australis*																	

	Site	7											8				9									
	Depth category	-1		0			1				2		-1		0		-1		0			1		2		
	Habitat	R		R			R		E		S		R		R		R		R			R		S		
Species/ Replicate search		1	2	1	2	3	1	2	1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	1	2	3
Ascidians	*Ascidiella aspersa*									2	3	3												2	4	3
	Eudistoma constrictum										2													1		
Barnacles	*Elminius* spp.													5												
	Unidentified barnacles	5	5										5				5	5								
Crustaceans	*Brachynotus spinosus*																									
	Carcinus maenas *	2	1	3		4	1			3			3	2	2	1										
	Cyclograpsus granulosus	3	3							1			3	3			3	3								
	Ebalia intermedia										1													2	2	2
	Halicarcinus ovatus		2			1								2		3	2	2							2	
	Halicarcinus rostratus																							1		2
	Helograpsus haswellianus																									
	Metacarcinus novaezelandiae *																									
	Palaemon dolospina																									
	Palaemon intermedius					3				3						3										
	Palaemon serenus			3	4			3							3	3				1	3	2	3			
	Paragrapsus gaimardii	4	4	3	3										3		4	4								
	Paragrapsus quadridentatus	2	1													1	2	3			2					
	Petrolisthes elongatus *	5	5	5	5		4	3					5	5	5	5	5	5	5		5					
Echinoderms	*Amphiura constricta*										3															
	Amphiura elandiformis											2														
	Asterias amurensis *				3	2	2	2	3	2	4	4			2	1				2	4		1	3	4	3
	Heliocidaris erythrogramma																						2			
	Meridiastra calcar					1																				
	Patiriella regularis *	5	5	5	5	5	5	4	2	3	4	3		4	5	5	5	5	5	5	5	4	4	5	4	
	Tosia magnifica																				1					
	Uniophora granifera																					1				
Flatworms	*Notoplana australis*				1																					

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 1–9) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand.

	Site	**1**				**2**				**3**				**4**				**5**											**6**						**7**											**8**				**9**									
	Depth category	**-1**		**1**		**-1**		**0**		**-1**		**1**		**-1**		**1**		**-1**		**0**			**1**					**2**	**-1**		**0**	**1**			**-1**		**0**			**1**				**2**		**-1**		**0**		**-1**		**0**			**1**		**2**		
	Habitat	**R**		**R**		**R**		**R**	**E**	**R**		**R**		**R**		**R**		**R**		**R**			**R**			**E**		**S**	**R**		**R**	**R**		**S**	**R**		**R**			**R**		**E**		**S**		**R**		**R**		**R**		**R**			**R**		**S**		
Species/ Replicate search		**1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**1**		**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**3**
Molluscs	*Austrolittorina unifasciata*																																																	4	4								
	Bembicium melanostomum																												1																	1													
	Bembicium nanum																	1	1																2	1														1									
	Cellana solida																																																		1								
	Chiton glaucus *																																																	1									
	Crassostrea gigas *	2	2	5	5	3	3	4	3	3	3	5		3	3	5		3	3	4	4	4	5	3			2		5	4	4				3	3	4	3	3		4	2				5	4	4	3	4	4	5	4	4	2				
	Ischnochiton australis																																						1													1							
	Ischnochiton elongatus																													1																													
	Mytilus galloprovincialis			5	2	5	5	5	5	5	5	5	2	5	5	5	5	5	5	5	5	5		5	4		4		5	4	4		3		5	5	5	5	5	3	5		2			5	5	4	4	5	5	5	3	5	2				
	Ostrea angasi		3										5				5				2	3			3	1	3		2		2		3							3	1					1	2	3	4										
	Pecten fumatus																																																									1	
	Phallomedusa solida		3																																																								
	Pleurobranchaea maculata																																	1											2														
	Siphonaria diemenensis																												1																														
	Siphonaria funiculata																	2																																3	3								
	Siphonaria spp.																													2																													
	Sypharochiton pelliserpentis																																																1		1								
	Tatea huonensis	5	5																																																								
	Xenostrobus pulex	5	5			3	3			3	3			3																																													
	Xenostrobus securis				5																																																						
Polychaetes	*Myxicola infundibulum* *												2										3			3	3	4						5								4	4	4	5												4	5	5
	Polynoid polychaete																																						1																				
	Sabellid spp.																																												2													2	
	Unidentified invertebrates (tube matting)																				5		5		5		3											5		5		1	3														5		3
Species richness (total sps per depth & habitat)		9	10	3	5	7	8	6	5	9	8	6	8	9	8	7	6	12	12	5	8	8	6	7	7	6	10	6	10	11	6	4	7	4	10	11	7	9	10	7	7	5	9	7	7	8	9	9	12	13	13	5	4	8	4	3	8	8	6
Total species richnes (total sps per site)		15				14				13				15				23											21						28											17				29									

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 10–18) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand.

	Site	10				11		12		13										14								15				16		17						18									
	Depth category	-1		0		2		2		-1		0			1			2	3	-1		0		1		2	3	-1		0		2		2						-1		0		1		2	
	Habitat	R		R		S		S		R		R			E			E	S	R		R		R		S	E	R		R		R								R		R		R		E	
Species/ Replicate search		1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	3	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	1	2	1	2	1	2	1	2	1	2
Ascidians	*Ascidia sydneiensis*						2	1	2										3	3								5					2																1
	Ascidiella aspersa					5	4		4										2	2																												
	Botrylloides spp.														1			2																														
	Ciona intestinalis																															1															
	Herdmania grandis																															2															
	Pyura australis																																															1
	Pyura gibbosa																																										4					
	Pyura stolonifera																												3			2	3					2				3	5					
	Sycozoa spp.																																												3		3
	Unidentified ascidians														1			1											1																			
Barnacles	*Catomerus polymerus*																																		3							4	4						
	Chamaesipho tasmanica	5	3																									5							5	3						5	5						
	Elminius spp.																												5																		
	Unidentified barnacles									5	5									5	5																												
Cnidarians	*Actinia tenebrosa*																					3												3	4	3						3	3						
	Cyanea rosella																																															
	Oulactis mucosa																					2					2								2								4	4						
	Phlyctenanthus australis																																2															
	Unidentified anemone																										2																					
Crustaceans	*Bellidilia undecimspinosa*																		3																														
	Carcinus maenas *	2							1											4	4							1																				
	Cyclograpsus granulosus									4	4									3	2													3	3	2												
	Ebalia intermedia																	1		2																														
	Halicarcinus ovatus				2															1									1																				
	Halicarcinus rostratus					3												2	2																														
	Jasus edwardsii																																2	1															
	Lophopagurus nanus																																															
	Munida gregaria						2																																									
	Naxia aurita					2																																										
	Notomithrax ursus																	1																												1		1			
	Pagurid spp.								1																																								
	Paguristes frontalis																																														2	
	Palaemon intermedius				3																																											
	Palaemon serenus			3	3										2							3	2										2													2		2
	Paragrapsus gaimardii	2		2	2						1									2	1							2	3							3												
	Paragrapsus quadridentatus	1			2															3	2							2	1						1	2						2						
	Petrolisthes elongatus *	5	5	5	5					5	5	5	5	5		2	2	3		5	5		3	3				5	5	5	4			5	5	4	5	5	4	4		5	4	5	4	3			
	Strigopagurus strigimanus					2																										1															
	Unidentified crab														1																																	
	Unidentified crab (decorator)						2		2																																							
	Unidentified hermit crab																																															

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 10–18) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	10				11		12		13										14								15				16		17						18							
	Depth category	-1		0		2		2		-1		0			1			2	3	-1		0		1		2	3	-1		0		2	2	-1			0		1			2	
	Habitat	R		R		S		S		R		R			E			E	S	R		R		R		S	E	R		R		R			R		R			E	
Species/ Replicate search		1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	3	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	3	1	2	1	2	1	2
Echinoderms	*Amblypneustes ovum*																																												
	Asterias amurensis *		1	3	2	3	4	4	4			4	4	4		3	2	3	2	2				3	3			4	1	2	2	2		2	2	3	4								
	Australostichopus mollis																	1							2																				
	Clarkcoma canaliculata																																												
	Coscinasterias muricata														1							2			1																				
	Goniocidaris spp.																									1																			
	Goniocidaris tubaria																								1																				
	Heliocidaris erythrogramma														3	3	3	3		2					2					3			2	3						4	4	5				
	Meridiastra calcar																																										2	2		
	Patiriella regularis *	5	4	5	5					3	3	5	1		3	4	3			2		3	3	5	5	3			2	2	4	4	5	4	5			1	2	2		4	2	3			2	3	1		
	Tosia australis																																	1											1	1		2
	Tosia magnifica																																	1													
	Uniophora granifera																		1																										1			
Echiurans	*Ikeda* spp.																															2															3
Flatworms	*Notoplana australis*																													2																
	Paraplanocera spp.																				1																										
	Unidentified flatworm																											1		1								2								
Molluscs	*Aplysia parvula*																																						2							
	Aplysia spp.					1																																								
	Aplysia sydneyensis			1																								1		1																
	Austrocochlea constricta		2																		2													1								2	3				
	Austrocochlea spp.																																													
	Austrolittorina unifasciata									4	4									4	4													5	3	3							5			
	Bembicium auratum	1																																												
	Bembicium nanum																				2																										
	Brachidontes rostratus																																										5			
	Cabestana spengleri																																													
	Cellana solida																											2						3	2	2						4					
	Chiton glaucus *	1								2			2							3	3							1	2					2			3	3	2	1		2	1	2			
	Chlorodiloma odontis																																										2				
	Clypidina rugosa																																									2				
	Cominella lineolata																											3	3					3	4	4						3	4				
	Crassostrea gigas *									3	3			2						4	4					3		4	4					3	3	3		3					2				
	Dicathais orbita																																		2	1				1		4	3				
	Diloma concamerata																																											2			

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 10–18) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	**10**				**11**		**12**		**13**										**14**								**15**				**16**		**17**								**18**									
	Depth category	**-1**		**0**		**2**		**2**		**-1**		**0**			**1**			**2**	**3**	**-1**		**0**		**1**		**2**	**3**	**-1**		**0**		**2**	**2**		**-1**			**0**		**1**			**2**	**-1**		**0**		**1**			**2**		
	Habitat	**R**		**R**		**S**		**S**		**R**		**R**			**E**			**E**	**S**	**R**		**R**		**R**		**S**	**E**	**R**		**R**		**S**	**R**		**R**			**R**		**R**	**E**	**S**	**R**	**R**		**R**		**R**			**E**		
Species/ Replicate search		**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Molluscs	*Haliotis rubra*																																																			
	Ischnochiton australis											1											1								2	3																				
	Ischnochiton variegatus																																				1														
	Lepsiella vinosa																											3																							
	Maoricolpus roseus *														4	2																																				
	Mytilus galloprovincialis	5	5	5	4					5	5	5	5	4		2					5	5	5	5					5	5	4	3		4	5	5	4	5	4		3			5	5							
	Notoacmea flammea																																																	
	Notoacmea petterdi																																	3																
	Ostrea angasi																						3			2						5			1		3	2				1								
	Patella (Scutellastra) chapmani																														2																			
	Patella (Scutellastra) peronii																											3										3												
	Patelloida latistrigata										2																																						
	Pecten fumatus															1										1																								
	Plaxiphora albida																							1																								
	Pleurobranchaea maculata																																																
	Siphonaria diemenensis									4	4										5	5							5			4			5									5							
	Siphonaria funiculata									3	2																		2	4							5									4				
	Sypharochiton pelliserpentis				1					3	3		3								3	4		3					3	3				4	3	3	4	3					3	3						
	Turbo undulatus																																													3		3			
	Unidentified chiton																															1																2			
	Xenostrobus pulex																																												5				
Polychaetes	*Galeolaria caespitosa*																																												4				
	Myxicola infundibulum *					5	4	5	3							5	5	5								5									5														4	4	5			5	4
	Sabellastarte spp.					3																																													
	Sabellid spp.																	3	3							4	3						3																1	3			2	
	Unidentified invertebrates (tube matting)						4	3	4						2			3					4																											1					3
Species richness (total sps per depth & habitat)		9	6	7	10	7	8	4	8	11	12	5	6	4	6	6	7	9	6	7	6	13	16	5	9	6	1	8	7	4	17	17	7	9	8	6	7	14	19	16	7	11	4	12	5	11	21	22	9	6	9	8	6	10
Total species richnes (total sps per site)				16		12		8							34										37								33								46										54				

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 19–24) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m... Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	19								20								21		22								23		24									
	Depth category	-1		0			1		2	-1		0			1		2			-1			0		1		2		2		-1		0			1		2	
	Habitat	R		R			R		R	S	R		R			R		E	S	S		R			R			E	S	S		R		R			R		E	S
Species/ Replicate search		1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	1	2	1	2	3	1	2	1	2	1	1	2	1	2	1	2	3	1	2	1	1
Ascidians	*Ascidia sydneiensis*																3	5	3								1	3	4	3									4
	Ascidiella aspersa																										1												
	Cnemidocarpa radicosa																											2											
	Herdmania grandis													3		2	3																						
	Herdmania momus																		2										3										
	Pyura australis														5		2	4					5		4		3							4					
	Pyura gibbosa			4	5	4		3			4		5			4	3							4		3				3	2	5	5	5	5	4	4		
	Pyura stolonifera	3	3								4	5	3	5				5		4	4	2	5							3	3	2	5						
	Sycozoa spp.																		1							1	1											1		
Barnacles	*Catomerus polymerus*	5	4							4	4										4									5	5								
	Chamaesipho tasmanica	5	5							5	5										5	3								5	5								
	Elminius spp.		3																	5																			
	Tetraclitella purpurascens	4	3																																				
	Unidentified barnacles											5											5																
Cnidarians	*Actinia tenebrosa*	2	2																	3	3	3								4	4				3			
	Anthothoe albocincta				4						3												4							2	3		4						
	Aulactinia veratra									2	3																												
	Corynactis australis																2										3					2	5						
	Culicia spp.															5											3												
	Cyanea rosella																																					1	
	Epiactis spp.							3								3	3															1							
	Oulactis mucosa	3	3										1																	2	2	4			3				
	Phlyctenanthus australis							1					4	3	3	3									2		2			2	2			4		3	2		
	Unidentified anemone							1																															
Crustaceans	*Cyclograpsus granulosus*	2								3	3										3	3	3							3	3								
	Jasus edwardsii			3	3	3	3	2	3			1			3	2																							
	Notomithrax ursus										2																								1				
	Pagurid spp.																		1										1										
	Pagurixus handrecki																	3																					
	Paragrapsus quadridentatus																					2																	
	Petrolisthes elongatus *	4	4		4	2					3				3					4	4	3		4		3				4	5			4		5			
	Plagusia chabrus				1			1																										1					
	Strigopagurus strigimanus																	2																					
	Unidentified crab (decorator)																		2																				
Echinoderms	*Amblypneustes ovum*																								1	4													
	Asterias amurensis *																	4	4								2	2	4	1									
	Australostichopus mollis																																	1	1				
	Comanthus tasmaniae															1																							
	Comanthus trichoptera						3	2	3							2																							
	Coscinasterias muricata														1		2												1						1	1	3	2		

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 19–24) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	19									20									21		22								23		24									
	Depth category	-1		0			1		2		-1		0			1		2		2		-1			0		1		2		2		-1		0			1		2	
	Habitat	R		R			R		R	S	R		R			R		E	S	S		R			R		R		E	S	S		R		R			R		E	S
Species/ Replicate search		1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	2	1	1	2	1	2	1	2	3	1	2	1	1
Echinoderms	*Heliocidaris erythrogramma*							2	2							3	3	2			1					3	3	2	2								2	3	2	
	Meridiastra calcar	3	3									2	4		3	3	4	2								1						4	4	4	4	3	4	4	3		
	Patiriella regularis *																					1		1		2	1							2							
	Tosia magnifica																												2	1								1		
	Uniophora granifera																																					1		
Echiurans	*Ikeda* spp.																			2	1								1											
Flatworms	Unidentified flatworm																										2													
Molluscs	*Afrolittorina praetermissa*																					3																		
	Agnewia tritoniformis																															1								
	Aplysia spp.																			1										1										
	Argobuccinum pustulosum				2																								1							1			
	Austrocochlea constricta	2	3								3	4										2										4	4							
	Austrocochlea spp.			2													2																						
	Austrolittorina unifasciata		5								5	5										5	5	3							5	5							
	Bembicium melanostomum																														1	2							
	Bembicium nanum																														3	2							
	Brachidontes rostratus	5																																					
	Cabestana spengleri				1			1					3	3	2	4	3	3		2					2		2			2		1		2		3	3		1	
	Cabestana tabulata																1																						
	Cellana solida	4	3									3		4									3	3	2						2	3				1			
	Chiton glaucus *																					3				1						1							
	Chlorodiloma odontis	3			2																																		
	Clanculus undatus																										1								4				
	Cominella lineolata	2	3			2						3																			4	4				1	2		
	Crassostrea gigas *				4	2		3			3	2	3		4		3					4	4	4		4		4			3	3							
	Dicathais orbita	2	3		1	2						2	2	1	3										1	2						2	2	3	3					
	Diloma concamerata		3																													2							
	Haliotis rubra				1											1	2																2				3	2		
	Ischnochiton australis																										1												
	Ischnochiton elongatus											2																												
	Mytilus galloprovincialis	4	4								5	4	4	5	5	5	3	3				5	5	4	5	5	4	5			5	5	5	5	3		3			
	Notoacmea flammea										1	1				2									5														
	Notoacmea petterdi																					2			4														
	Octopus tetricus																			1																				
	Ostrea angasi						4	1	3						4	5	3	3									4	3	3						4	2		4	3		

Appendix 5. cont. Rank abundances of invertebrates recorded during timed surveys (sites 19–24) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	19									20									21		22								23		24									
	Depth category	-1		0			1		2		-1		0			1		2		2		-1			0		1		2		2		-1		0			1		2	
	Habitat	R		R			R		R	S	R		R			R		E	S	S		R			R		R		E	S	S		R		R			R		E	S
Species/ Replicate search		1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	1	1	2	1	2	3	1	2	1	2	1	1	1	2	1	2	1	2	3	1	2	1	1
Molluscs	*Patella (Scutellastra) peronii*		3																							3								3		4		2				
	Patelloida latistrigata		3																																							
	Patelloida victoriana																								2																	
	Plaxiphora albida											2														1							2	3								
	Pleurobranchaea maculata																																					1				
	Pleuroploca australasia																												1			1									
	Ranella australasia																									2														2		
	Sassia verrucosa																		1																							
	Siphonaria diemenensis	4																					5		4																
	Siphonaria funiculata		3								4	4											3											5	5							
	Siphonaria tasmanica	1																																							
	Sypharochiton pelliserpentis	2	2		2						3	3											4	3	3									4	4							
	Turbo undulatus			2	4	4		2	2					3	2	4	2																		3	4		3	3	1	
	Unidentified chiton																																						2		
	Xenostrobus pulex		5								5	5																						5	5							
Polychaetes	*Galeolaria caespitosa*		3																				4											4								
	Myxicola infundibulum *																				5	5							2	3	5	5									
	Sabellastarte australiensis																										2														
	Sabellastarte spp.																				2																				
	Unidentified serpulids																					3																				
Species richness (total sps per depth & habitat)		19	22	4	12	8	3	12	5		12	21	8	7	12	14	18	12	3	9	12	16	12	13	11	12	10	10	13	6	5	7	24	29	12	11	8	16	15	13	2
Total species richnes (total sps per site)		43									44									17		52									9										

Appendix 6. Rank abundances of algae and plant species recorded during timed surveys (sites 1–9) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m.. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	**1**			**2**				**3**			**4**			**5**													**6**						**7**								**8**				**9**										
	Depth category	**-1**		**1**	**-1**		**0**		**-1**		**1**	**-1**		**1**	**-1**		**0**			**1**						**2**	**-1**		**0**	**1**			**2**	**-1**		**0**			**1**				**2**	**-1**		**0**	**-1**		**0**			**1**		**2**			
	Habitat	**R**		**R**	**R**		**R**	**E**	**R**		**R**	**R**		**R**	**R**		**R**			**R**			**E**			**S**	**R**		**R**	**R**		**S**	**R**		**R**		**E**			**S**	**R**		**R**	**R**		**R**			**R**		**S**			
Species/ Replicate search		**1**	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	**3**
Brown algae	*Cladostephus spongiosus*																																																					
	Unidentified algae (filamentous brown)			5			5											5				5							4		3							5	5	3								5								5
Green algae	*Codium fragile*																														2				3																			
	Codium harveyi																																																				
	Codium spp.																																				1																	
	Ulva spp. (f. *Enteromprpha*)	5	5	4	5	5		2	5	5		5	5	4	5	5		3	2		2							4						5	5	4		3								5				5	5				
	Ulva australis							1											3		2																																		
	Ulva spp.								3	4	5	3	3	5	4	4		3																																						
	Unidentified algae (filamentous green)			5																									4	2					2			2		1						5									
Red algae	*Aeodes nitidissima* *																																																					
	Gracilaria ramulosa						5																																															
	Unidentified algae (filamentous red)			5															4	5			3															5	4				4													
Other algae/ plants	*Heterozostera tasmanica*	5	5		5	5	5	3																																															
	Sarcocornia quinqueflora	5	5		1	2																																															
	Unidentified algae (turf)	2	2		2	2			2	2		3	3		2	2				5															2	2													5						
Species richness (total sps per depth & habitat)		4	4	4	4	4	3	3	3	3	1	3	3	2	3	3		2	4	2	2		2				1	1	2		2			2	2	3		4		4	1	3			2	1	2	2	2	2		2		1		1	
Total species richnes (total sps per site)			7			7				3			3						6										4									9								6						7			

Appendix 6. cont. Rank abundances of algae and plant species recorded during timed surveys (sites 10–18) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	10				11		12		13												14										15							16		17														18									
	Depth category	-1		0		2		2		-1		0			1			2		3		-1			0		1			2	3	-1			0			2		2			0		1				2		-1			0		1			2	
	Habitat	R		R		S		S		R		R			E			E	S	S		R			R		R			S	R	R			R			R		R			R		R			E	S	R			R		R			E	
Species/ Replicate search		1	2	1	2	1	2	1	2	1	2	1	2	3	1	2	3	1	2	3	1	1	2	1	2	3	1	2	1	2	1	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	3	1	1	2	1	2	1	2	1	2	1	2
Brown algae	*Acrocarpia paniculata*																																																											
	Carpoglossum confluens																																																											
	Caulocystis cephalornithos																																																										
	Caulocystis uvifera																																																										
	Cladostephus spongiosus											5	4																																															
	Colpomenia sinuosa																																																										
	Cystophora monilifera																																																										
	Cystophora moniliformis																																																										
	Cystophora retroflexa																																																										
	Dictyopteris muelleri																																																										
	Dictyota dichotoma																																																										
	Dictyota spp.																																																										
	Distromium flabellatum																																																										
	Ecklonia radiata																																																										
	Halopteris paniculata																																																										
	Hormosira banksii																																																										
	Lessonia corrugata																																																										
	Sargassum fallax																																																										
	Sargassum spp.																																																										
	Sargassum verruculosum																																																										
	Sporochnus comosus																																																										
	Undaria pinnatifida *																																																										
	Unidentified algae (brown turf)																																																										
	Unidentified algae (filamentous brown)																																																										
	Zonaria turneriana/angustata																																																										
Green algae	*Codium duthieae*																																																										
	Codium fragile																																																										
	Codium harveyi																																																										
	Codium spongiosum																																																										
	Codium spp.																																																										
	Ulva spp. (f. *Enteromprpha*)																																																									
	Ulva australis																																																										
	Ulva spp.																																																										
	Unidentified algae (filamentous green)																																																										
Red algae	*Aeodes nitidissima* *																																																									
	Dasya spp.																																																										
	Gigartina recurva																																																										
	Gracilaria spp.																																																										
	Grateloupia turuturu *																																																										
	Unidentified algae (filamentous red)																																																										
	Unidentified algae (red)																																																										
Other algae/ plants	Unidentified algae																																																										
Species richness (total sps per depth & habitat)		2	2	5	4			1	1	2	2	4	3	4	3	2	1	2	1	2		4	4	4	4	3	1		2			3	5	3	1		4	8	3	3	2	6	3	1	9	1		6	3	8	10	12	9	1	
Total species richnes (total sps per site)		10				0		2		14												12										10							19														23									

Appendix 6. cont. Rank abundances of algae and plant species recorded during timed surveys (sites 19–24) in February-March 2010. Depth categories: -1= intertidal; 0 = 0–0.9m; 1= 1–4.9m; 2 = 5–8.9 m; 3 = 9–15m. Habitat categories: R = reef; E = ecotone (reef-sand); S = sand. * = introduced species.

	Site	19									20									21	22										23	24									
	Depth category	-1		0			1			2	-1		0			1			2		2	-1			0		1		2		2	-1		0			1			2	
	Habitat	R		R			R			R	S	R		R			R			E	S	S	R			R		R			E	S	S	R		R			R			E	S
Species/ Replicate search		1	2	1	2	3	1	2	1	1		1	2	1	2	3	1	2	1	1		1	2	1	2	3	1	2	1	1		1	2	1	2	1	2	3	1	2	1	1
Brown algae	*Acrocarpia paniculata*			3		3	3	3	4		2					3	4							2	3	4									3	3	3				
	Bellotia eriophorum																																								2
	Carpoglossum confluens						4	3	4							5	3	3						3	5	4	4									4						
	Caulocystis cephalornithos			2		2		2																3		2																
	Caulocystis uvifera								3																																	
	Cladosiphon filum												2																													
	Cladostephus spongiosus				3		3		2					3										3		2							4	4								
	Cystophora moniliformis			3	4	4		3	4		2		3		4	5	3						4	3	3	3						4	3	3	4	3					
	Cystophora retorta											2																													
	Dictyopteris muelleri			2	4	2	4	3	4				2	3	2	4	3	3					4	2	4	3	2					3			3	3					
	Ecklonia radiata			2		2	5	4	5				3			4	3	4						4	4	4	4					3		4	5	4	4				
	Halopteris paniculata								2																																
	Hormosira banksii											3																				3	3								
	Lessonia corrugata			3	5	4	4	3	5				4	5	4	5	4	3				2	3	5	4	4	4					3	3	4	4	4	3	3			
	Macrocystis pyrifera																																			3	2	2				
	Phyllospora comosa																																				2				
	Sargassum fallax				3	2		3	3		2												1	1		3	3								3	2	2				
	Sargassum spp.																																2	3								
	Sargassum verruculosum			2			5	3	5								3	3							2		2									2	2				
	Sargassum vestitum			2	4								3	3		3	3	2						4									4		2							
	Sporochnus comosus						3																																		
	Undaria pinnatifida *			2	3	3	3	2	4				3	3	4	4	3	3																	3	4	3	4	3	3	
	Unidentified algae (filamentous brown)					3																																		
	Zonaria turneriana/angustata					1		2				1			1		2	2									3									2		3				
Green algae	*Caulerpa brownii*								4							4																				5					
	Caulerpa geminata																																				2				
	Caulerpa longifolia								4									1																								
	Caulerpa simpliciuscula			2		3		2										2																			1	2				
	Caulerpa trifaria			2				2	4									3																			4	3	3			
	Chaetomorpha coliformis					2																														3						
	Cladophora spp.		3																																						
	Codium fragile		2										1		2							3				2								3	2		5				
	Codium harveyi								2								1																									
	Codium spongiosum													5		5											3															
	Codium spp.											1																								2	2					
	Ulva australis		3	2		3		2				4	1	4		4		2	2				2			4		3						4	4	3		5		3	1	
	Ulva spp.	4			4				3						5		3					5		4	4		3										4				
	Unidentified algae (filamentous green)																																			2						
Red algae	*Grateloupia turuturu* *													3		3						3		3			3										4				
Species richness (total sps per depth & habitat)		1	3	12	8	13	9	14	17			5	4	9	7	8	11	12	13				4	3	2	6	12	10	9	5				7	6	8	5	8	11	16	11	1
Total species richnes (total sps per site)						27										26				0					17					0						28				